P-Gamer: A Domain-Independent Platform for Tailoring Persuasive Games and Studying their Effectiveness.

by

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To every young human trying hard to make an honest living.

"Keep hustling. One day, your perseverance will surely pave a path for you."

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ABSTRACT

Persuasive games for health are interventions designed to promote behaviour change through various persuasive strategies. Understanding the effectiveness of these strategies before implementing them is crucial in the design lifecycle of persuasive systems. There is a growing need for quick, cost-effective methods to evaluate persuasive gamified systems before their release. Therefore, we propose a domain-independent persuasive game framework to assess the effectiveness and user responses elicited by persuasive strategies.

Furthermore, while research has demonstrated the effectiveness of persuasive strategies in motivating behaviour change, there is limited knowledge about the impact of application domains and game framing on the effectiveness of these strategies. To address these gaps, after a comprehensive systematic review of persuasive games in research, we developed a platform called P-Gamer—a domain-independent persuasive game platform—to evaluate the effectiveness and user responses of persuasive strategies. We conducted usability studies to assess (a) the usability of the P-Gamer Platform. Additionally, we generated persuasive games from the platform and conducted a study involving 371 participants to investigate (b) the impact of application domains on the perceived effectiveness of persuasive strategies; (c) the impact of game framing on the perceived effectiveness of persuasive strategies; (d) the impact of game framing on the relationship between the effectiveness of persuasive strategies and their motivational appeal; and (e) the relationships between gamer types and the perceived effectiveness of persuasive strategies across game framings.

Our results show that the P-Gamer platform was usable and could easily be used to generate persuasive games and associated studies without the need for coding. The findings also revealed that application domains and game framing significantly influence the perceived effectiveness of persuasive strategies, particularly concerning gamer types and the motivational appeal of the implemented strategies. We offer design suggestions for developing persuasive games for health, tailored to individual preferences based on these factors.

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CHAPTER 1 INTRODUCTION

Persuasive games are gameful systems with the primary purpose of promoting behaviour or attitude change [51][111][26][121]. They leverage the immersive and interactive nature of gaming to engage players in experiences that go beyond mere entertainment. They incorporate elements of game design, narrative, and mechanics strategically to encourage players to adopt desired behaviours or attitudes. Whether it's encouraging players to adopt healthier lifestyle choices, promoting environmental awareness, or fostering empathy towards certain social issues, persuasive games harness the power of gameplay to effect meaningful change. To achieve these behaviour change objectives persuasive games employ various principles which are popularly known as Persuasive Strategies [129][8]. Research has shown that persuasive games are effective at promoting behaviour changes across many domains [5][66][126]. As a result, in recent years, we have witnessed a growing investment in the design and development of persuasive games targeted at solving problems in various domains including environmental sustainability [55][60][15], promoting personal wellness, managing diseases [6][74][84], engaging in preventive behaviours, physical activity [53][33], healthy eating [119][117][116], avoiding risky behaviours, and substance abuse [56].

Although persuasive games have been effective at behaviour change, it has been shown that one-size-does-not-fit-all when it comes to designing persuasive games to motivate behaviour change and that a persuasive strategy that works well for a user or user group may not work for others. It is imperative to consider various ways to easily tailor persuasive games to user characteristics to increase their effectiveness at motivating the desired behaviour change [123]. Therefore, there is a need for systems that facilitate tailoring as well as swift and straightforward testing of persuasive strategies throughout the design lifecycle of persuasive games. This ensures that persuasive game designers can efficiently experiment with different approaches to persuasion, gather feedback, and make iterative improvements without significant delays.

1.1 The Problems

In this section, we shall highlight the major problems we addressed in this research.

1.1.1 The need for a persuasive game study platform

To design effective persuasive games, it is important to evaluate and compare the effectiveness of the persuasive strategies to be employed, to guide design choices. This is a big challenge in the field of persuasive games since games take a lot of time and resources to design. Furthermore, system design in the modern-day is fast becoming plug-and-play and persuasive game designers are always actively looking for fast, cost-effective and robust ways of iteratively evaluating their systems during the design lifecycle, to meet the evolving needs of users.

1.1.2 The Impact of Application Domain and Game Framing on the Effectiveness of Persuasive Games

Although persuasive games have been proven to be effective over the years, the effectiveness of these games is impacted by a variety of factors. For example, research has shown that the effectiveness of persuasive games can be impacted by individual differences-related factors such as age groups [166][132], gender groups [132][167], gamer types [123], gamification user type [122], and personality types [125][11]. These factors are mostly individual differences-related factors. While the effect of individual differences-related factors has gained some attention, the effect of other contextual factors such as persuasive game design-related contextual factors on the effectiveness of persuasive games has hardly been explored. Two important game-context or game-design-related factors that can influence the effectiveness of persuasive games are game framing and application domains.

Game framing refers to the deliberate and strategic design of a game's context, mechanics, and objectives [156]. Generally, there are three main types of framing: gain-framing [92], loss-framing [171] and gain-loss-framing[49, 94]. In the field of persuasive games, where engagement meets behaviour change, the relationship between game framing and persuasive strategies is paramount. Game framing not only establishes the foundation for integrating persuasive game elements but also shapes players' perceptions of the game's purpose, context, and challenges. Consequently, it may influence the effectiveness of the persuasive strategies that are embedded within the game to motivate players toward specific behaviours or attitudes.

Therefore, it is research-worthy to explore the relationships between game framing, persuasive strategies and persuasive game effectiveness This exploration will enable persuasive game designers and researchers to fully harness the persuasive potential of behaviour change games.

Also, application domains refer to the behaviour change goals that the persuasive game is focused on. There are many application domains in persuasive game research including disease prevention [28][108], Healthy Nutrition [78][119] and Physical Activity [33][42]. Each of these domains presents unique challenges and opportunities for persuasion. For instance, strategies that are effective in encouraging individuals to adopt healthier eating habits may not necessarily translate well to efforts aimed at increasing STD awareness [103]. Therefore, investigating the differences in the effectiveness of persuasive games across these distinct application domains may provide valuable insights into the underlying mechanisms that drive behaviour change. This understanding can help in the design of more tailored and context-sensitive persuasive technologies, ultimately enhancing their effectiveness.

1.2 The Solutions

To solve the first problem and achieve our first major research objective, we developed P-Gamer, a domain-independent persuasive game platform for examining the effectiveness and user responses evoked by persuasive strategies. This platform also enables easy plug-in of persuasive strategies. It equips persuasive technology designers of any level of expertise to create persuasive games and test out the effectiveness of various strategies and implementations with minimal design effort and little or no coding, before releasing them to the wild. We achieved this research objective through the following steps:

- We conducted a comprehensive systematic review of existing persuasive games, to understand current trends in persuasive games research. This review allowed us to examine how persuasive strategies are implemented in behaviour change games. The findings from this review led to the publication of two research papers: one in IEEE Transactions on Games and another presented at the IEEE International Conference on Serious Games and Applications for Health [104, 105].

- Based on these reviews, we conducted an initial large-scale study using prototypes of popular persuasive strategies across two domains: healthy eating and smoking cessation. This study aimed to understand how the effectiveness of these strategies varies across different domains. The results of this study were published in the User Modeling and User-Adapted Interaction Journal [103].
- Furthermore, through an iterative design process, we developed a low-fidelity prototype for the P-Gamer platform.
- Next, we conducted a usability study on the platform, with six experienced persuasive design experts to provide valuable insights into its usability.
- Based on the low-fidelity prototype and the insights from the usability study, we designed the web-based P-Gamer platform that allows persuasive game designers to quickly develop persuasive games based on popular predefined criteria.
- Following that, we conducted another round of usability evaluation on the platform to ascertain whether the improvements recommended during the low-fidelity stage improved its ease of use.

To address our remaining research objectives, using the P-Gamer platform, we generated some persuasive games for Healthy Eating and STD awareness. Then we carried out a large-scale between-study involving 371 participants, using the framing type as the between-factor, to investigate the following:

- The impact of application domains on the effectiveness of persuasive strategies
- The impact of game framing on the effectiveness of persuasive strategies
- The relationship between the effectiveness of persuasive strategies and their motivational appeal (ARCS Motivational Appeal Model) [86], across game framings.
- The effectiveness of persuasive strategies implemented in the games, for various users' gamer types (HEXAD model) [163], across game framings.

1.3 Research Questions

This dissertation contributes to advancing the field of Human-Computer Interaction and persuasive technology by effectively answering four major research questions:

RQ1: How usable is the P-Gamer Platform for generating persuasive games and game studies?

RQ2: What is the impact of application domains on the perceived effectiveness of persuasive strategies across game framings?

RQ3: What is the impact of game framing on the perceived effectiveness of the implemented persuasive strategies?

RQ4: What is the relationship between the effectiveness of the persuasive strategies and their motivational appeal across game framings?

RQ5: What are the relationships between gamer types and the effectiveness of persuasive strategies across game framings?

1.4 Research Contributions

This thesis offers four main contributions that advance the field of Human-Computer Interaction and Persuasive games:

1. **Development of a Domain-Independent Persuasive Game Platform**: We introduced and designed a domain-independent persuasive game platform for investigating the effectiveness and user responses to persuasive strategies. The platform's usability was evaluated through the design of persuasive games and game studies, demonstrating its effectiveness in creating and assessing persuasive game interventions.
2. **Impact of Application Domains on Persuasive Strategies**: Through a comprehensive large-scale study, we explored how the application domain affects the effectiveness of persuasive strategies (Reward, Competition, Praise, and Suggestion) across two specific domains: healthy eating and STD awareness, using the P-Gamer platform. This study provided valuable insights into how domain context influences the effectiveness of these persuasive strategies.
3. **Impact of Game Framing on Persuasive Strategies and Motivational Appeal**: We examined how game framing influences the perceived effectiveness of persuasive strategies and their relationship with motivational appeal within a healthy eating persuasive game generated using the P-Gamer platform. Our findings revealed that game framing significantly impacts the effectiveness of persuasive strategies. It also showed that game

framing influences the relationship between persuasive strategies and motivational appeal dimensions (attention, relevance, confidence, and satisfaction). For example, of the four persuasive strategies, only the Reward and Suggestion strategies maintained a consistent relationship with all motivational appeal dimensions across different game-framed versions.

4. **Effectiveness of Persuasive Strategies Across Gamer Types and Game Framings**: We explored the relationship between the effectiveness of persuasive strategies and gamer types across different game framings. This investigation revealed some important insights for persuasive game designers, highlighting the need to consider gamer types and game framing in game design. For instance, the Reward strategy showed significant relationships with all gamer types in the gain-framed persuasive game, while the Suggestion strategy did not show significant relationships with any gamer types across all framings.

These findings from our studies shed light on the importance of considering the game framing, motivational appeal, and gamer types in designing more effective persuasive games. By exploring these relationships, we provide valuable insights for researchers, practitioners, and game designers aiming to harness the potential of persuasive gaming interventions for promoting positive behaviour change.

1.5 Overview of Dissertation

This dissertation has seven chapters and, in this section, we shall briefly summarize each chapter.

CHAPTER 1 INTRODUCTION: This chapter gives an overview of the thesis, the problems and their solutions, and the major research questions addressed by this dissertation.

CHAPTER 2 RESEARCH BACKGROUND: This chapter provides an in-depth review of relevant literature review related to this work. It discusses research in various aspects including persuasive strategies, persuasive software platforms, motivational appeal, gamer types, framings and perceived effectiveness of persuasive strategies.

CHAPTER 3 P-Gamer Design and Evaluation: This chapter describes the iterative design and evaluation process of the P-Gamer platform.

CHAPTER 4 Exploring the Impact of Application Domains on the Effectiveness of Persuasive Strategies: This chapter explores the effectiveness of four persuasive strategies across two distinct application domains: Healthy Eating and STD Awareness. It aims to determine whether there are any significant differences in the effectiveness of these strategies across these two domains.

CHAPTER 5 Exploring the Impact of Game Framing and the Effectiveness of Persuasive Strategies and their Motivational Appeal: This chapter discussed the study design and results of a between-study of the perceived effectiveness of persuasive strategies with respect to game framing. It also explores the impact of game framing on the relationship between the effectiveness of persuasive strategies and their motivational appeal.

CHAPTER 6 The Impact of Game Framing on the Effectiveness of Persuasive Strategies for Gamer Types: This chapter discussed the results of a between-study on the impact of game framing on the effectiveness of persuasive strategies for gamer types. It presents how different gamer types responded to four persuasive strategies in a healthy eating persuasive game across different game framings.

CHAPTER 7 Discussion: This chapter presents a discussion of all the results collected in this research.

CHAPTER 8 Conclusion: This chapter presents the contributions of this dissertation and outlines its limitations and future works.

CHAPTER 2 Research Background

In this section, we provide the necessary background for the work conducted in this paper. We give a brief overview of existing persuasive system design frameworks, how persuasive strategies were implemented in some persuasive applications, and specifically how the four persuasive strategies have been implemented in research. Additionally, we review research concerning persuasive software platforms, motivational appeal, gamer types, motivational appeal, framings, and the perceived effectiveness of persuasive strategies.

2.1 Persuasive Strategies

Persuasive strategies are techniques and principles employed in technological interventions to promote positive behaviour change [111]. Over the years, a growing number of research has been targeted at developing persuasive strategies that can be employed in persuasive gamified systems design. For example, Cialdini [161] proposed six principles for influencing human behaviour; Michie et al. [97] proposed Behaviour Change Technique Taxonomy; Fogg proposed seven persuasive tools [51]; Oinas-Kukkonnen et al. [111] built on Fogg's work to develop 28 persuasive strategies for motivating behaviour change.

Among all these frameworks and models, the PSD model developed by Oinas-Kukunnen et al. [111] has been widely employed in persuasive gamified systems design [2][37][35][23] due to its comprehensive nature. It combines strategies from other frameworks and offers some guidelines on how the strategies can be translated into software components in persuasive gamified systems design. Hence, we base our research on this framework. A list of four commonly used persuasive strategies from the PSD framework selected for our study and their descriptions are shown in Table 1.

Table 1 - Four persuasive strategies and their descriptions.

Strategies	Description
Rewards	Offering positive incentives or reinforcements to players, such as points, badges, or virtual loot boxes, to motivate and encourage desired behaviours or actions.
Competition,	Encouraging players to compete with others, thereby motivating them to achieve desired goals or outcomes using techniques such as social challenges, ranking charts and leaderboards.
Praise	Utilizing positive feedback or compliments to reinforce desired behaviours or achievements.
Suggestions	Offering recommendations to players and suggesting specific actions or behaviours to motivate them to adopt desired habits or decisions.

2.2 Persuasive Strategies and Implementations

Research indicates a growing trend in the development and utilization of persuasive games across diverse fields. In this section, we shall explore the implementations of four persuasive strategies (rewards, competition, praise, and suggestions) in persuasive system research across various domains.

2.2.1 Reward

The reward strategy involves offering positive incentives or reinforcements to players, such as points, badges, or virtual loot boxes, to motivate and encourage desired behaviours or actions [111]. This strategy has been widely used in many persuasive systems and game research to promote behaviours across various domains. For example, 'Nourish Your Tree'[128], a persuasive game for physical activity rewards players with badges and points for completing behaviour change. In Evitapp, users earn badges and points upon achieving set goals [21]. Similarly, in LunchTime, a slow-casual game promoting healthy eating [119], players receive points for every healthy meal choice. The 'SilverCycling' system, comprising an augmented reality bike for encouraging physical activity in older adults, rewards users with points for cycling specific distances [10].

Similarly, Almonani et al.'s persuasive mobile game targeting childhood obesity utilizes points to motivate children to exercise regularly [7]. The FoodWorks game implemented badges to encourage children to consume their food portions without leftovers [57]. Fanning et al. [47] incentivized users to achieve physical activity goals by awarding program points and badges within their application. Point-based rewards were also employed by Haque et al. [70] and Zuckerman et

al. [177] to incentivize users for every additional walking step taken, with Haque et al. [70] offering badges to top-performing users. The MoviPill application awards points to users for adhering to their medication schedules [114].

In ‘SmokeScreen’ – a persuasive game aimed at motivating high school students to avoid risky behaviours that could lead to tobacco abuse – players are rewarded with game progress and points for making healthy decisions [135]. On the other hand, applications such as GoalPost and GoalLine, [100] offer ribbons to users as they progress toward their goals and trophies upon goal completion. TreeCare [131] offers trophies to motivate users to engage in physical activity. Other implementations of the reward strategy include streak coins [131] and animated graphics, such as virtual roses [4].

2.2.2 Competition

The competition strategy encourages players to compete with others, thereby motivating them to achieve desired goals or outcomes using techniques such as social challenges, ranking charts and leaderboards [111]. One of the most popular implementations of the competition strategy is the use of leaderboards to rank users based on their accomplishments. For instance, in the study by Altmeyer et al. [10], a leaderboard was utilized to rank users according to the distance covered while cycling. Similarly, the LunchTime game [119] employed a leaderboard feature to assess players' adherence to dietary goals, promoting healthy eating habits. The Strava application [19] features a leaderboard for active cycling challenges, while the TreeCare application [131] ranks players in individual-based challenges and team-based tournaments to encourage physical activity.

Fadda et al. [46] introduced a leaderboard in a gamified application aimed at increasing parental knowledge of MMR vaccination, ranking users based on quiz scores. Additionally, the NUGU application [87] presents individual and group scoreboards to showcase user rankings, while Pechenkina et al. [134] utilized leaderboards to enhance student engagement and academic achievement. Lentelink et al. [90] depicted individual players' progress along a journey map, resembling a racetrack, indicating their position relative to others based on step counts. Similarly, the Health Buddies application [41] employed a racetrack feature to display players' progress

towards the finish line in medication adherence challenges. StepMatron [52] designed to promote physical activity in the workplace, ranks users on a Leaderboard based on step counts, akin to the iGO application [70]. Furthermore, the MoviPill application [114] offers a Leaderboard ranking users based on their medication compliance scores.

2.2.3 Praise

The praise strategy utilizes positive feedback or compliments to reinforce desired behaviours or achievements [111]. For instance, Purpura et al. [139] employed the praise strategy in their healthy diet application, sending text-based messages to users whenever they adhered to a balanced diet and exercise regimen to meet their goals. In contrast, Pollak et al. [136] represented praise by displaying the facial image of a happy dog when users consumed a healthy diet, while another application combined text and images to provide visually appealing praise elements to further motivate users [76].

Mumm et al. [98] incorporated the praise strategy into their game by delivering both text-based and verbal messages to commend players for their exemplary performance (e.g., "Nice job. Keep it up."). Similarly, Adamo et al. [2] utilized behaviour-specific praise through text messages to encourage physical activity among school students (e.g., "Good job running the stairs", "Good Job! I like the way you run"). Other studies have also employed text-based messages to praise users for their physical activity levels throughout the day [45] and for achieving individual step goals [164].

Additionally, STD Pong 2.0, a persuasive game for disease management implemented the praise strategy as text-based messages such as good job or well done and congratulatory images such as green checkmarks and confetti, for defeating STDs in the game and answering the knowledge test questions correctly [107]. Moreover, the PEIR sustainable environment application praised users with a green icon of trees if their carbon consumption or pollution exposure remained low [99]. Similarly, the Quitty smoking cessation application utilized text-based congratulatory messages accompanied by visual icons to offer praise [133].

2.2.4 Suggestion

The suggestion persuasive strategy involves offering recommendations to players and suggesting specific actions or behaviours to motivate them to adopt desired habits or decisions [111]. An example of suggestion implementation can be found in healthy eating apps such as DietApp [89] and HeartHealth [127], which deliver personalized dietary advice through features such as "Dietary Suggestions" and "Tips." Siawsolit et al. [155] developed a health-conscious grocery shopping app that presents pop-up messages suggesting alternative healthy food options to users after selecting products.

BlueWatch [54] a mobile intervention targeting the well-being of adults experiencing depressive symptoms, incorporates the suggestion strategy by providing a list of recommendations accessible through the "My Tasks" feature. Additionally, Nutrihealth, [149] a healthy diet app for the elderly calculates users' Body Mass Index (BMI) and offers a selection of suitable menus/foods for consumption.

Chen et al. [30] employed another approach by sending motivational messages and suggestions via the short messaging service (SMS) to aid users in their smoking cessation journey. Anagnostopoulou et al. [13] integrated the suggestion strategy into their app to promote sustainable travel choices. They associated persuasive messages with various transportation modes, displayed as alerts within the app. Furthermore, smoking cessation applications employ the suggestion strategy. Hassandra et al. [71] provide in-app and tailored activity suggestions to manage cigarette cravings.

2.3 Persuasive Software Frameworks

Software framework/platforms and toolkits help to guide and reduce the development time of systems. They also help researchers focus more on the study details and less on the development of the systems. Since we designed a software framework for designing persuasive game studies (P-Gamer), it is important to review some existing software frameworks for designing persuasive systems.

The Patient Clinician-Designer (PCD) is a software framework for designing persuasive mobile phone monitoring systems for managing mental illness [95]. The framework applies a user-centred approach that takes into account various elements of the illness such as its complexity, stigma complexity, and patient/doctor goals. The researchers also designed the MONARCA system based on this framework to demonstrate how it overcomes the challenges of designing persuasive monitoring systems for mental illness. Similarly, the 'Persuasive by Design' is a model and toolkit that helps professionals to design evidence-based health interventions [73]. This model includes both the contexts and intervention strategies, displaying them in a set of colour-coded layers (a blue layer – with different modes of behaviour, i.e., reflective and automatic, a red layer that displays biases for behaviour change, and a green layer displaying the social influences on human behaviour. Persuasion Knowledge Toolkit (PToolkit) is a toolkit that helps to transfer persuasion knowledge to designers [147]. The toolkit guides designers in the early design phase, providing them with the required knowledge for making effective persuasive systems. Furthermore, Oja et al. proposed a framework to guide the creation and evaluation of persuasive games and applications [113]. Their proposed framework facilitates the creation and evaluation of persuasive systems by providing tools for accessing measurement data, managing avatars and enabling ubiquitous accessibility. They considered two different approaches: the use of gamification and the use of serious games. However, they did not design the framework or carry out any evaluation of it.

In our work, we present the design and usability evaluation of a software framework for developing persuasive games and evaluating the effectiveness of various strategies. This tool would help designers rapidly create persuasive games with little or no game design expertise and also help them collect user data for evaluation.

2.4 Framings and Persuasion

Numerous studies have shown the pivotal role of framing in enhancing user engagement across various communication mediums, including messages, applications, and games. Thoughtfully framing system features can nurture emotional connections, promote immersion, and facilitate identification with system elements, thereby amplifying users' or players' motivation to actively

engage and learn from the content. Despite these benefits, research indicates varying outcomes concerning the influence of gain and loss framing on behaviour change.

In the research conducted by Lim et al. [92], the impact of message framing, specifically gain-framed performance feedback, on users' intentions to adopt fitness apps was explored. The study revealed that gain-framed messages surpassed loss-framed messages in effectively increasing users' intentions to utilize the fitness app. This suggests that a positive or gain-oriented presentation within a fitness app significantly influences users' intentions regarding app adoption. Similar findings in the context of fitness apps were supported by Yadav et al. [170], who investigated the efficacy of gain and loss-framed messages in an exercise app, demonstrating the superiority of gain-framed messages in encouraging exercise performance. Schlottmann [153] also underscored the preference of both children and adults for gain framing over loss framing.

Conversely, research by Ye et al. [171] discovered that loss-framed messages were more effective in increasing intentions to get vaccinated compared to gain-framed messages. This revelation stemmed from an investigation into the impact of message framing and presentation on the promotion of vaccination behaviour during a public health crisis. Additionally, Roby [142] demonstrated the effectiveness of loss framing in improving coordination within a minimum-effort game.

In this work, we shall be considering the impact of three different framing types on the effectiveness of persuasive games. They are gain framing, loss framing, and gain-loss framing. Table 2 shows a description of each framing type.

Table 2 - Game Framing types and their descriptions

Framing Type	**Description**
Gain Framing	This refers to the strategic design and presentation of the game's context, mechanics, and objectives with a focus on emphasizing the potential benefits or gains associated with taking specific actions within the game.
Loss Framing	This approach involves integrating elements of game design and gameplay mechanics while emphasizing the potential losses or negative consequences associated with not engaging in desired behaviours or actions within the game.

Gain-Loss Framing	This approach integrates elements of game design and gameplay mechanics while strategically emphasizing both the potential gains and losses associated with specific behaviours or choices within the game.

2.5 Motivational Appeal Constructs

Since we will also be exploring the motivational appeal of persuasive strategies, it is important to review research on motivational appeal constructs. There have been numerous research that tries to understand human motivation. They have resulted in motivational theories, such as Self-determination theory [145] and Expectancy–Value theory [169] and the ARCS model of motivation [86]. The ARCS model of motivation is based on research in the psychology of human motivation to identify four key constructs that drive and sustain motivation: Attention, Relevance, Confidence, and Satisfaction [86].

In this research, we opted for the ARCS model because it is a widely applied and established motivational model [143], with components derived from a comprehensive synthesis of research on human motivation [1]. Additionally, the ARCS model serves as a robust macro-theory that integrates various notable motivational theories, including the Self-Efficacy theory, Expectancy-Value theory, Reinforcement theory, Social learning theory, and Cognitive Evaluation theory [86, 157].

Moreover, since the ARCS motivation model has demonstrated associations with behaviour and behaviour change [59], human-computer interaction and persuasive technology researchers have utilized the ARCS model to guide the design and evaluation of behaviour change interventions. For instance, it has been widely employed to assess the motivational appeal of persuasive systems across diverse domains such as health interventions[9, 158], and persuasive games [40, 174]. Abdessettar applied the ARCS motivation model in creating a persuasive smart mobile school for children [1], and Zulkifli et al. used the ARCS questionnaire to evaluate the motivational appeal of an interactive persuasive system [157]. Various persuasive system designers have also incorporated elements of the ARCS motivation model into their intervention designs. For example, Stockdale et al. integrated the Confidence construct of the ARCS model in a persuasive

intervention to promote breastfeeding among first-time mothers, aiming to boost their confidence in their breastfeeding ability [158]. Similarly, Yusoff et al. [176] adapted the Attention construct to enhance the motivational appeal of persuasive elements within their persuasive game. Table 3 provides a summary of the four ARCS model of motivation constructs, adapted from Orji et al. [115] and Oladapo et al. [130].

Table 3 - The constructs or dimensions of the ARCS Model of Motivation

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 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.

2.6 Gamer Type Models

Game design research has identified that gamers' behaviour patterns significantly influence their engagement and response to games, particularly in the context of persuasion. Hence, over the years, game researchers have come up with various ways of classifying them. In this work, we will refer to these classifications as gamer type models. In this section, we will explore the various attempts by game researchers to classify gamers according to their behaviour patterns.

Barlte's Player Type Model [20], which is one of the earlier models in this field, classifies gamers into four types: which are Achievers – *players who focus on goals and accomplishments within the game*, Explorers – *players who enjoy discovering new aspects of the game world*, Socializers – *players who prioritize social interaction and relationships*, Killers – *players who thrive on competition and conflict with other players*.

Furthermore, Yee expanded upon Bartle's model by identifying ten motivational factors driving player behaviour in Massively Multiplayer Online Role-Playing Games (MMORPGs) [172]. Yee's model provided insights into the diverse range of gamer motivations for playing games which are achievement, socialization, immersion, escapism, building relationships, customization, discovery, role-playing, competition, and skill development.

Likewise, the Quantic Foundry model [173], through large-scale surveys, offered a comprehensive understanding of player preferences across different gaming genres and platforms. It classifies gamers into different twelve gamer motivations. They are *action, social, mastery, achievement, immersion, creativity, camaraderie, strategy, relaxation, challenge, excitement,* and *completion.*

Some other proposed models for categorizing gamers include the Myers-Briggs Type Indicator (MBTI) for Gamers – which applies personality types to gaming preferences[101], the BrainHex Player Typology, which categorizes players into cognitive and affective archetypes[102], the Player Experience of Need Satisfaction (PENS) Model – which emphasizes the psychological needs satisfied by gaming experiences, including autonomy, competence, and relatedness[144].

In the field of persuasive technology and persuasive games, a popular gamer type model used in understanding gamers' behaviours towards various persuasive elements is called the HEXAD Gamer Type Model[163]. This model was proposed by Andrzej Marczewski, and combines Bartle's player types with other psychological frameworks to create six gamer type classifications which are: Achiever, Socializer, Philanthropist, Free Spirit, Player, and Disruptor. Table 4 shows a description of these gamer types. We shall use this model in this work to understand the impact of game framing on various gamer types.

Table 4 - The HEXAD gamer types and their descriptions.

Gamer Type	**Description**
Achiever	Goal-oriented players who strive for completion and mastery.
Socializer	Players who prioritize social interaction and community building.

Philanthropist	Players who derive satisfaction from helping others and contributing to the community.
Free Spirit	Players who seek freedom, exploration, and creativity.
Player	Balanced players who enjoy various aspects of gaming without extreme preferences.
Disruptor	Players who challenge norms and enjoy breaking rules or causing chaos.

2.7 Perceived Effectiveness of Persuasive Technologies

Many theories have highlighted that attitude is a predictor of behaviour including the theory of planned behaviour and the theory of reasoned action. In this work, we measure the effectiveness of persuasive strategies implemented in the persuasive systems using the participants' perception of their persuasiveness. Although there is a difference between perceived persuasion and actual persuasion, it is common for researchers to assess belief or perception as a precursor of actual behaviour or effectiveness. Specifically, research shows that perception can be used to inform design decisions (in line with user-centred design) and predict actual behaviours. For example, a TOCHI paper [118] shows the relation between perception and actual behaviour by showing that a persuasive technology (PT) informed by models developed based on users' perception [121] was more effective than a generic one. The effectiveness of self-report-driven personalization of PT in actual behaviour has also been shown in multiple other areas including eCommerce, physical activity and snacking [82][83]. In line with this, it is widely acknowledged in the area of PT that both explicit measures (users' tendencies (perception/self-assessment) to comply with distinct persuasive strategies) and implicit measures (actual responses) are effective approaches to PT design and both have been shown to be effective - Kaptein et al. [83]. "Such an explicit approach could be used to tailor persuasive applications: if we have a questionnaire that elicits the tendencies of individual users to comply to distinct influence principles we would be able to measure these tendencies a priori and adapt the interaction with the user according to the obtained estimates" – Kaptein et al. [83]. Hence, our findings hold promise for designing PTs to promote actual behaviour outcomes.

CHAPTER 3 P-Gamer Design and Evaluation

In the previous chapter, we provided an overview of existing persuasive system design software frameworks/platforms. In this chapter, we address our first research question – *RQ1: How usable is the P-Gamer Platform for generating persuasive games and game studies?*[1] Specifically, we explore the design and evaluation of the P-Gamer low-fidelity prototype. Then, we explore the implementations and evaluation of the actual P-Gamer platform that takes the suggestions from the low-fidelity evaluation into account. This chapter addresses the following sub-research questions.

RQ1a: How usable is the P-Gamer low-fidelity prototype, in general?

RQ1b: How easy is it to use the major features of the P-Gamer low-fidelity prototype?

RQ1c: What are the design issues with the P-Gamer low-fidelity prototype and how can they be improved?

RQ1d: How usable is the actual P-Gamer platform, in general?

RQ1e: How easy is it to use the major features of the P-Gamer platform?

As an initial step to this project, we carried out systematic reviews and compared existing persuasive games from various domains such as physical activity, disease control, healthy eating, and environmental sustainability[2,3]. The data from the systematic analysis helped us to determine some important elements of the framework. For example, the analysis revealed that casual games

[1] Originally published in **Chinenye Ndulue** and Rita Orji. 2023. A Usability Evaluation of a Software Framework for Designing Persuasive Games. In Adjunct Proceedings of the 31st ACM Conference on User Modeling, Adaptation and Personalization (UMAP '23 Adjunct). Association for Computing Machinery, New York, NY, USA, 123–128. https://doi.org/10.1145/3563359.3596988

[2] Published in **C. Ndulue** and R. Orji, "Games for Change - A Comparative Systematic Review of Persuasive Strategies in Games for Behaviour Change," in IEEE Transactions on Games, https://doi.org/10.1109/TG.2022.3159090

[3] Published in **C. Ndulue** and R. Orji, "Persuasive Games for Physical Activity in App Stores: A Systematic Review," 2022 IEEE 10th International Conference on Serious Games and Applications for Health(SeGAH), Sydney, Australia, 2022, pp. 1-6. https://doi.org/10.1109/SEGAH54908.2022.9978574

are the most popular genre for persuasive games. We also identified that reward and competition are among the most popular persuasive strategies in persuasive games [104].

3.1 P-Gamer Low-Fidelity Design

Before beginning the development of the P-Gamer platform, we identified some major elements of behaviour change games used in persuasive technology research. They include target framing, target domain, game concept, persuasive strategies to implement and also the user data to be collected. These elements informed the major sections of the P-Gamer platform. Figure 7 shows the proposed high-level flow diagram of the framework. In the following sections, we describe the six major sections of the platform.

3.1.1 Target Framing Section:

The target framing of persuasive games has been shown to have significant effects on the effectiveness of the overall game and the strategies implemented [124][36]. Persuasive games can be designed to have three types of framing, which are: loss framing, gain framing, and gain-loss framing [140, 154]. Games with loss framing focus solely on the disadvantages of the undesired behaviour. They are based on the belief that if the player sees or experiences the ill effects of the undesired behaviour, they would be willing to stop the behaviour. Loss avoidance has been shown to affect human behaviour [146]. Furthermore, games with gain framing focus solely on the advantages of the desired behaviour. They are also based on the belief that if a player experiences the good effects of the desired behaviour, they will be persuaded to do that behaviour. While the gain-loss framing focuses on both the disadvantages and advantages of the undesired behaviour and the desired behaviour respectively. In this section of the framework, an investigator is allowed to select any game framing type they want to implement in the study. Figure 1 shows a screenshot of the framing type section.

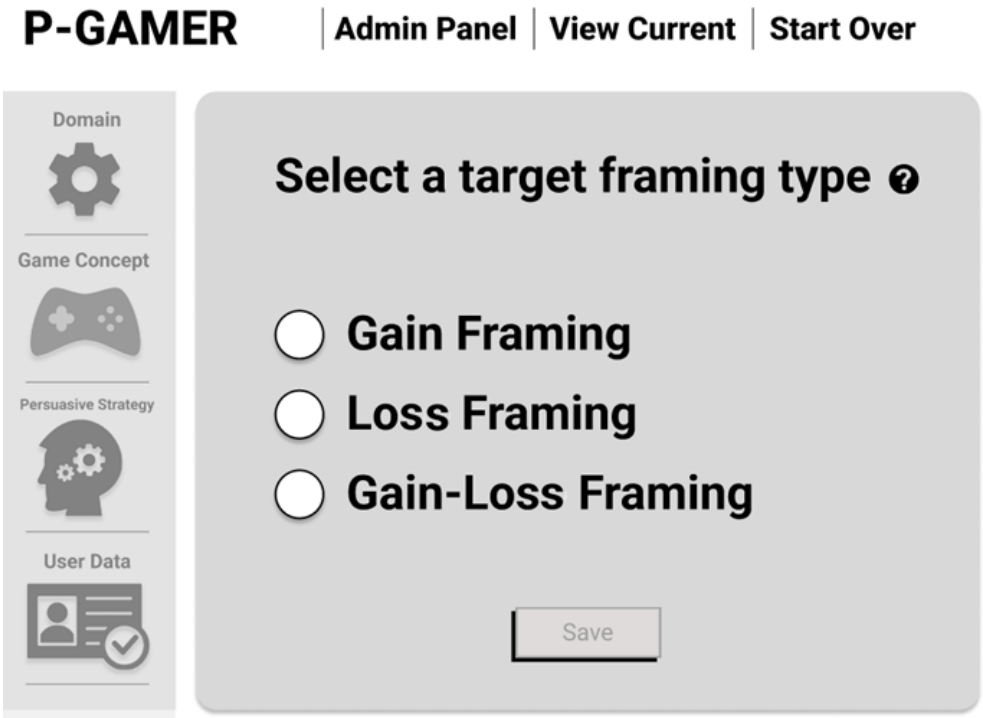

Figure 1 - Screenshot of the Target Framing Section

3.1.2 Target Domain Section

In every persuasive game, targeting a specific behaviour change domain is important. These domains can range from healthy eating [120], physical activity [34], and disease management [107], to preventing drug abuse [37]. Therefore, this section of the platform allows researchers to select the domain they are interested in. This iteration of the platform is scoped to allow researchers to select between two domains, namely healthy eating and STD awareness for a start. These domains are some of the popular domains identified from a systematic review we carried out on persuasive games existing in research [104]. Figure 2 shows a screenshot of the domain section.

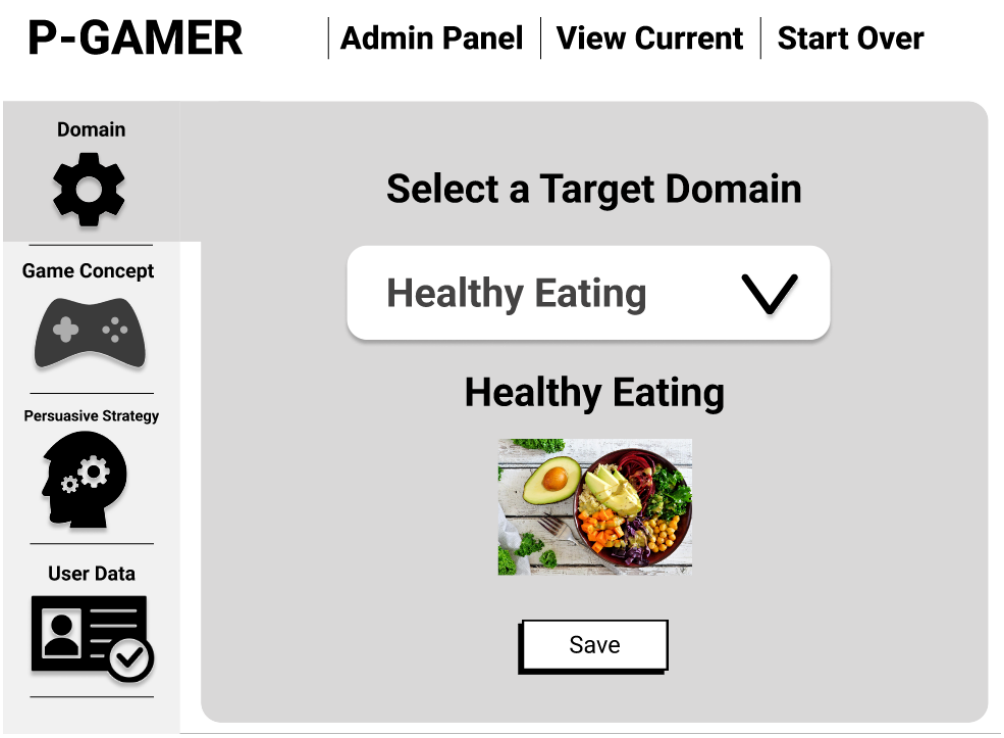

Figure 2 - Screenshot of the Domain Section

3.1.3 Game Concept Section.

Every persuasive game is based on a gaming concept and genre which would drive the persuasive content being implemented. This iteration of this platform is scoped to allow investigators to choose between two popular retro games: Pac-man and Space Invaders. Figure 3 shows a screenshot of the game concept section.

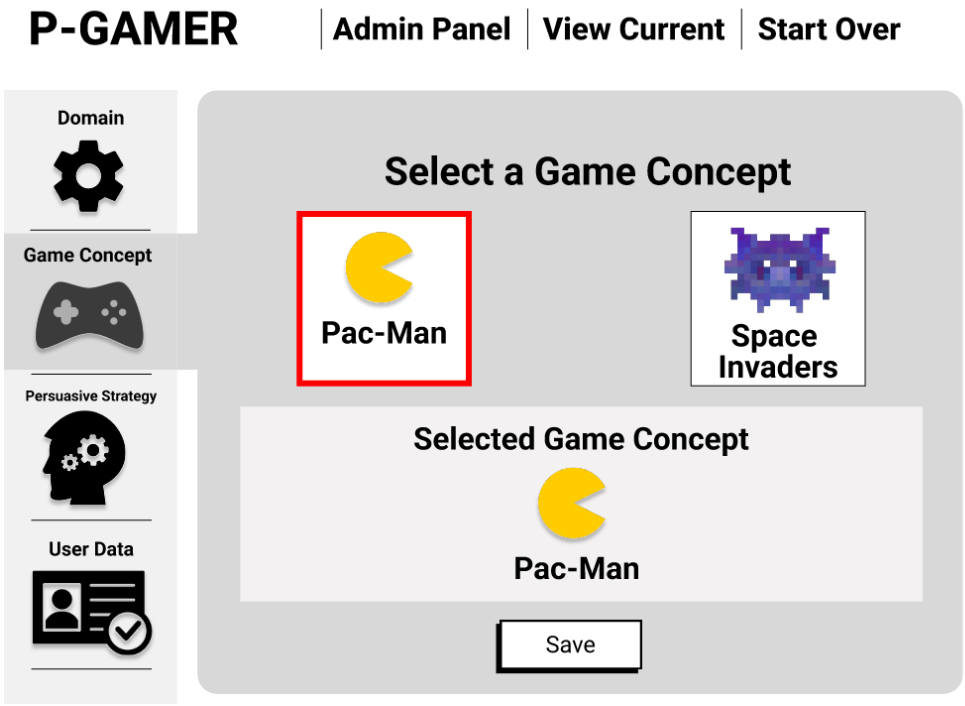

Figure 3 - Screenshot of the Game Concept Section

3.1.4 Persuasive Strategy and Implementations Section.

The main distinguishing factor between persuasive games and conventional games is the intentional implementation of persuasive strategies in persuasive games to motivate desired behaviour change. The platform allows investigators to select what persuasive strategies they want to implement and also how they plan to execute their implementation choices. For the first iteration of this framework, investigators are allowed to select between four different persuasive strategies (rewards, competition, suggestion, praise) and two different implementations for each. These implementations have already been proven to be effective in our previous research [106] and are popular implementations from the literature. Figure 4 shows a screenshot of the persuasive strategy section.

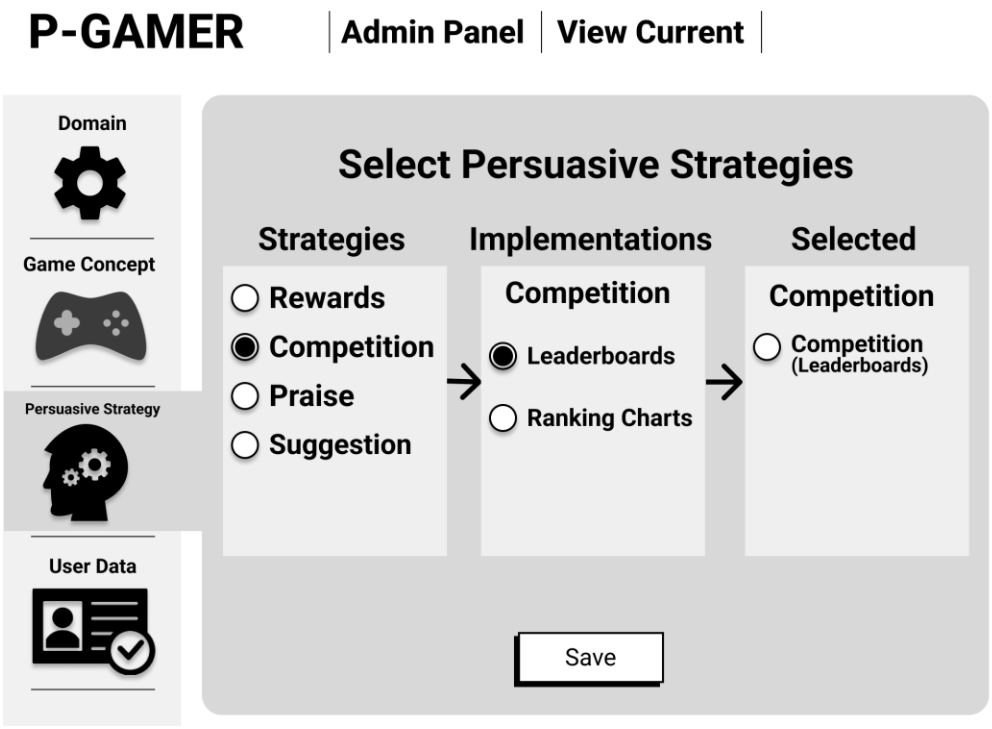

Figure 4 - Screenshot of the Persuasive Strategy Section

3.1.5 User Data Section

Every persuasive game study involves the collection of some form of data before, during and after the usage of the persuasive game. The P-Gamer framework allows investigators to select the types of user data they would like to collect with the created study. For the first iteration of this framework, it allows the investigator to be able to select demographic data, perceived persuasiveness data [43], motivational appeal data [40], gamification user type data [163], personality data [77] and player experience data [75]. These are based on predefined scales from research. Figure 5 shows a screenshot of the user data section.

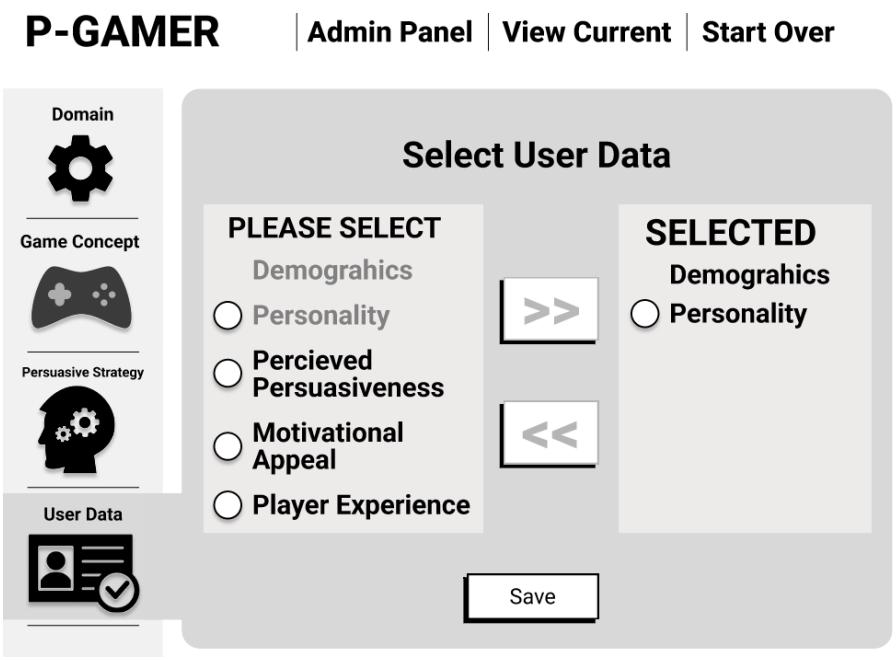

Figure 5 - Screenshot of the User Data Section

3.1.6 Admin Section

This section allows the investigator to manage the study, before, during and after its creation. It provides various features such as monitoring the number of participants in the study, downloading user data, terminating the study, generating study links etc. Figure 6 shows a screenshot of the Admin section.

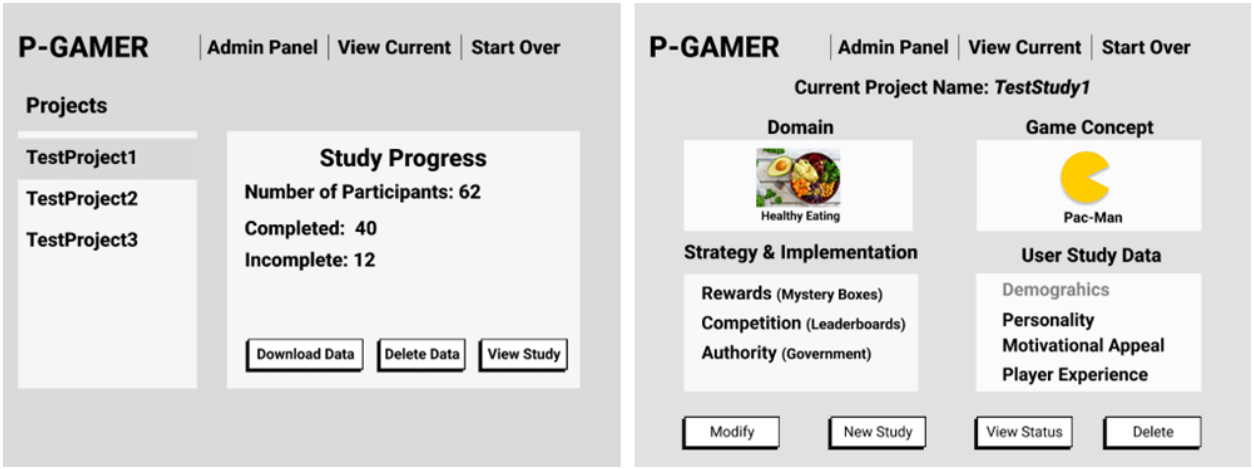

Figure 6 - Screenshot of the Admin Section

3.2 Study Design for the P-Gamer Low-Fidelity Prototype

To understand the usability of the P-Gamer framework and answer our research questions, we developed the prototypes of the P-Gamer framework to gain insights into the usability of the system before the actual development. Then, we carried out a usability evaluation study of the entire system. For this study, we recruited six persuasive system designers as experts, to evaluate the overall system and different features of the system, using unstructured interviews, observations, and surveys based on the System Usability Scale (SUS) [91] and the Single Ease Question (SEQ) [168]. The number of expert evaluators used is in accordance with Nielsen et al. [109] work on usability standards, which states that the number of evaluators should be between five to ten evaluators.

Each participant was invited to an online session, where we described the entire framework and how each of the features worked using the prototype. Then we recorded their initial feedback on the issues that they observed while explaining the system. After that, each participant was given a link to the interactive prototype to explore and identify any usability issues. Furthermore, we conducted an unstructured interview to uncover more insights about the issues that were identified in the overall system and associated features. After that, they filled out a survey where they rated the usability of the overall framework, using the SUS. Also, the Single Ease Question (SEQ) was used to measure the perceived task difficulty of the major sections of the P-Gamer framework.

The framework was divided into six different sections, namely: Target Framing Section, Target Domain Section, Game Concept Section, Persuasive Strategy Section, User Data Section and the Admin Section. After using each major section, the evaluators were asked to rate the ease of use using SEQ.

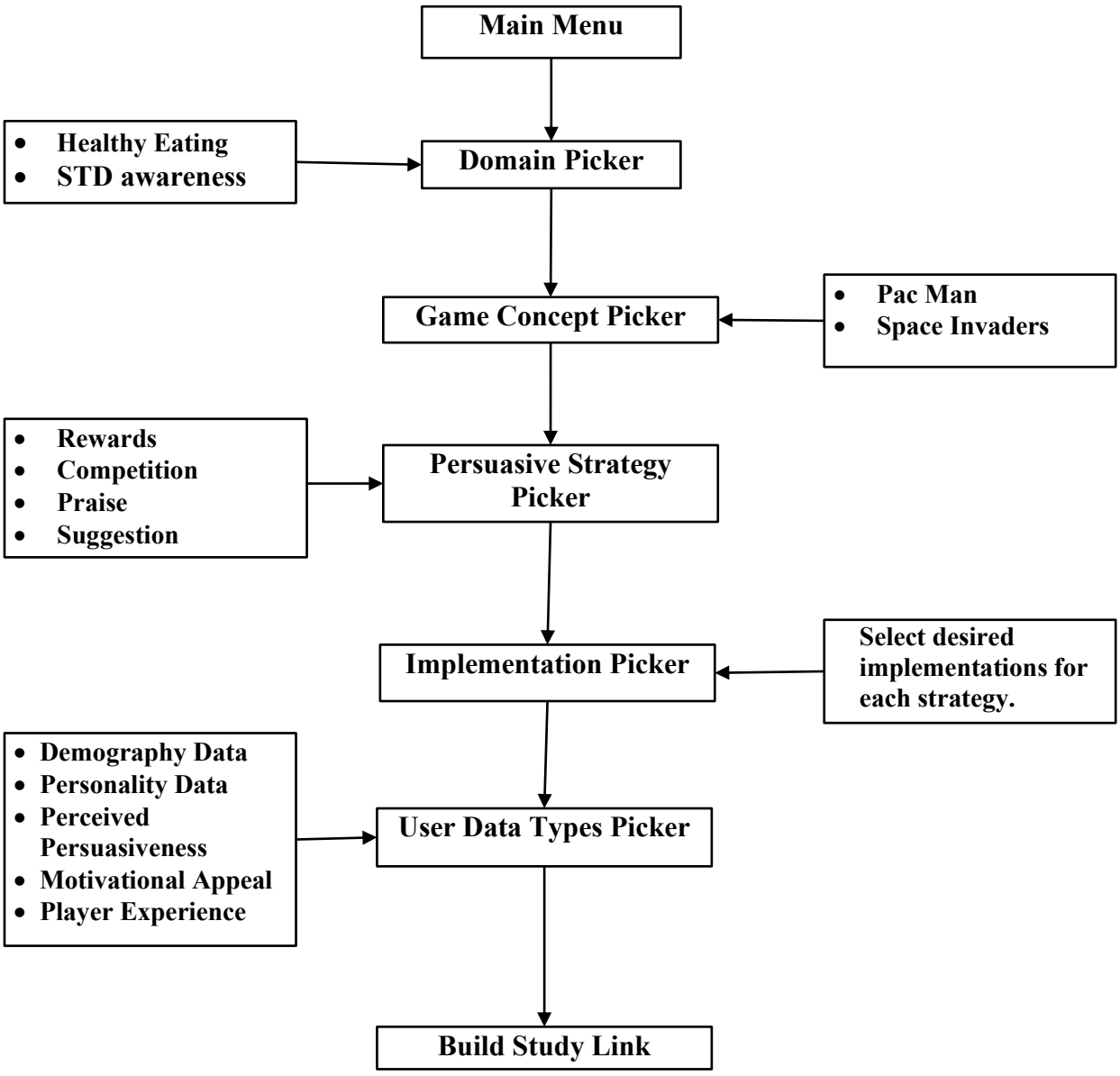

Figure 7 – A High-level flow diagram of the P-Gamer platform

3.3 Analysis and Results for the P-Gamer Low-Fidelity Prototype

To answer RQ1a – *How usable is the P-Gamer low fidelity prototype, in general?*, we calculated the SUS score of the system. We used the formula in equation (1), to calculate the overall SUS score of the system according to the ratings of the six evaluators [178].

$$SUS = 2.5\ (20 + \ SUM\ (SUS01, SUS03, SUS05, SUS07, SUS09) - \ SUM\ (SUS02, SUS04, SUS06, SUS08, SUS10))\quad (1)$$

The P-Gamer platform had an overall SUS score of 87.91 which is above the excellent score of 85, according to Bangor et al. [16] [17] interpretation of the SUS scores, as shown in Figure 8. This implies that the system was perceived to be highly usable by persuasive system designers.

To answer RQ1b – *How easy is it to use the major features of the P-Gamer low fidelity prototype?*, we ran one-sample t-tests on the SEQ scores for each major section in the platform. Our results showed that the mean values of the ratings of five sections were significantly higher than the nominal midpoint of 4. This implies that five of the sections of the platform were significantly easy to use. They are the Target Framing section ($t(5) = 11$, $p=.0001$), the Target Domain section ($t(5) = 11$, $p=.0001$), Game Concept section ($t(5) = 4$, $p=.010$), the persuasive strategy and implementation section ($t(5) = 6.325$, $p=.001$), and User Data Section ($t(5) = 6.325$, $p=.001$. However, the admin section rating, with a mean rating of 5.75, was only marginally significantly higher than the midpoint ($t(5) = 2.445$, $p=.058$). This is evident from the comments of evaluators, requesting more flexibility and features in the admin section. Table 7 shows the t-test results of the six major sections of the P-Gamer Low-Fidelity Prototype.

To answer RQ1c – *What are the design issues with the P-Gamer low fidelity prototype and how can they be improved?*, we conducted a thematic analysis of the unstructured interview responses and comments on major sections of the system. We grouped the feedback from participants into design problems and what the participants' liked. The design problems were extracted from the dislikes that were identified by participants. Table 6 shows lists of some design issues, what the participants liked and how they correspond to Neilson's heuristics [110]. We will discuss these issues in the next section.

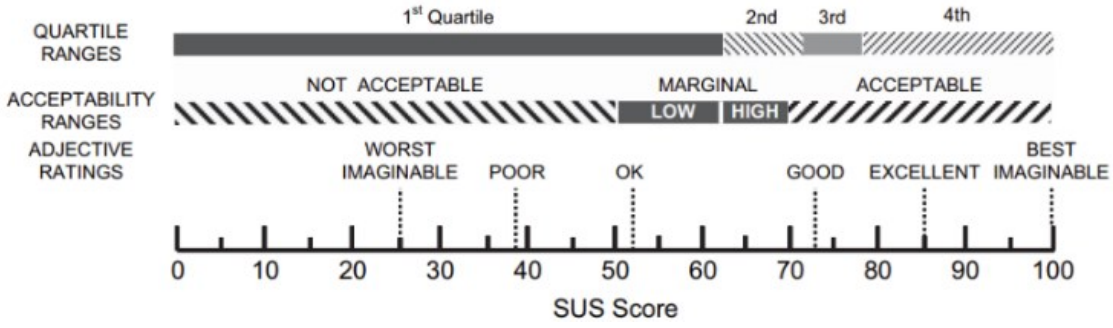

Figure 8 - SUS score rankings by Bangor et al.[16]

Table 5 - T-Test result of the ease of use for each major feature of the P-Gamer Low-Fidelity Prototype

P-Gamer Sections	t	df	Mean	SD	Sig
Target Framing	11.000	5	6.750	.6124	.000
Target Domain	11.000	5	6.750	.6124	.000
Game Concept	4.000	5	6.000	1.2247	.010
Persuasive Strategy	6.325	5	6.000	.7746	.001
User Data	6.325	5	6.000	.7746	.001
Admin	2.445	5	5.750	1.7536	.058

Table 6 - Some design issues and likes identified by evaluators.

Design Issues	Neilson's Heuristics
Limiting for researchers.	Flexibility and efficiency of use
Limited customization of the game concept.	Flexibility and efficiency of use
No sufficient guide for all important actions	Help and documentation
Navigation issues with the 'Next' and 'Back' button	User control and freedom
No page numbering to know what step the user is on	Visibility of system status
No tutorial about the system	Help and documentation
Confusion about icon meanings	Recognition rather than recall
The icons on the buttons are bigger than the text on the buttons	Consistency and standards
Likes	**Neilson's Heuristics**
The ease of coming up with a game quickly.	User control and freedom
Perfect linking from page to page.	User control and freedom
The info button for target framing helped.	Help and documentation
The simplicity of game concepts chosen.	Recognition rather than recall

3.4 Discussion for the P-Gamer Low-Fidelity Prototype

In this section, we discuss the findings from the interviews and comments about the P-Gamer platform based on Nielsen's heuristics [110].

3.4.1 Visibility of system status

Although each page had a title to identify the current page the user is on, an evaluator suggested the implementation of numbered pages.

"… and I think numbered steps would help the user know where they are." – P4.

This would automatically inform the user of the framework and how far they have gone in the study creation process. Since the platform looks procedural in nature, it is necessary that the users know the level of the current page. This can be achieved by having numbered steps. i.e. (1) Target Framing, (2) Target Domain, and so on. We can also implement a sidebar that lists the items that have been added to the study being created. The user should be able to edit the list at any stage in the creation process.

3.4.2 Flexibility and efficiency of use

Participants found some parts of the framework limiting when creating persuasive game studies. They suggested that the system should allow more customization of study elements. For example, P3 suggested the inclusion of custom games aside from the ones implemented, while P1 suggested the ability to change core elements of the provided game concepts, such as game assets and game stories, to suit the investigators' study ideas. This is an important suggestion since the more customization allowed in the framework, the more likely the framework would be used by persuasive game researchers with diverse game design ideas. Therefore, we plan to allow as much customization as possible to each section of the framework, especially to the user data section. We would allow the researcher to be able to not only choose the scales to implement for data collection but also be able to edit these scales to suit their study needs.

3.4.3 Help and documentation.

While the evaluators found the system very easy to use, some identified the absence of proper documentation for the system as expressed by the following comment:

"… If I had to nitpick, I'd say that there was no tutorial for the system. But everything was self-explanatory, and the flow was straightforward to start with." – P5.

We plan to correct this design issue by having an interactive tutorial to guide the users of the P-Gamer system. We also plan to have tooltips for each major function in each section to eliminate confusion. We would also implement a complete documentation page on the home screen of the framework.

3.4.4 User control and freedom

While using the prototype, the evaluators appreciated the ease of coming up with a persuasive game, as evident in the following comment:

"I enjoyed how easy it is to come up with a persuasive game and a study to go with it" – P1.

However, they identified the need for more control in the admin section of the framework. They stressed the need to allow investigators to select study duration and allow them to preview and analyze data deeply in the platform *(P5, P3*). This is true because the admin section may be the most important part of the platform for the investigator since that is where they can change study settings and also collect and view the progress of the study. To address this feedback, we have decided to add more functionalities to the existing ones which may include the ability to generate charts and graphs from the data collected, the ability to restart the study, the ability to automatically contact participants if need be and so on.

3.4.5 Recognition rather than Recall

We implemented very popular game concepts in the framework to improve the ease of recognition of the system since people are more drawn towards things that they recognize immediately than things they must remember or think about. An issue related to recognition and recall was confusion about some icons in the system. *P4* was confused about the icon for the target domain section, confusing it with a setting button while *P6* was confused about the target framing icon. We will correct this by checking existing research and changing all icons that do not conform to the existing standards.

3.4.6 Other Discussions

The P-Gamer platform would be an effective tool for persuasive games research that would help them to rapidly understand the effectiveness of the individual persuasive strategies they intended to implement in their games, considering how easy it would be to plug in persuasive strategies with the platform. They can easily create various versions of the same game, isolating individual persuasive strategies to understand their effectiveness among their target population. Furthermore, they would be able to study the effectiveness of these strategies across multiple domains easily. This would make it easy to conduct controlled persuasive game experiments that would further persuasive technology research.

However, the general design of this platform presents a trade-off between customization and the ease of making games. The less customization the investigator has in the platform, the easier and faster the system can be used to make persuasive game studies, as this would reduce the complexity of the platform. However, this would limit the scope of studies that can be created with the platform. On the other hand, adding many customizable features to the platform would make it more robust and usable for a wider range of persuasive game studies. Therefore, we need to find a fine line between proving an acceptable number of customizations in the platform that would allow persuasive system designers to develop studies within a meaningful scope while maintaining simplicity. Alternatively, some optional customization can be included as part of the system's advanced settings for experienced users who may need them.

3.5 P-Gamer Platform Usability Study

After addressing most of the suggestions for the low-fidelity prototype of the P-Gamer, we implemented the actual P-Gamer platform. We designed the P-Gamer platform using the ASP.NET framework, C#.net and an SQL database, while the games were designed using the Unity game engine, exported as WebGL games, and hosted on the P-Gamer platform. In this section, we provide an overview of how the P-Gamer platform functions through a specific use-case scenario. Additionally, we present the findings from a usability evaluation conducted on the platform. Appendix B shows other screenshots of the platform.

3.5.1 P-Gamer Platform Use Case

We shall describe the functionality of the P-Gamer platform through a practical use case of a typical researcher's interaction with the platform.

3.5.1.1 A Typical P-Gamer Scenario

Johnny is a persuasive technology researcher who wants to create a persuasive game to promote healthy eating. Despite lacking prior game design experience, he has a clear understanding of the persuasive techniques he intends to employ for this purpose.

3.5.1.2 Use Case Steps

i. The P-Gamer website shows a login page.
ii. Johnny clicks the “Create Account” button and successfully registers on the P-Gamer platform.
iii. The platform shows a sign-in page.
iv. Johny logs in using the account he created earlier.
v. The platform presents the main dashboard of the platform (Figure 9).
vi. Johnny initiates the development of a new study by clicking the "New Study" button.
vii. The platform presents a prompt, asking Johnny to enter the name of the new study.
viii. Johnny enters the study name as "Healthy Eating and Motivation" and proceeds by clicking "OK".
ix. The platform displays the "New Study" page, featuring tabs for selecting various study parameters.
x. Johnny navigates to the "Framing Type" tab and selects "Gain-Framing" for the game (Figure 10).
xi. Johnny navigates to the "Game Domain" tab and selects the "Healthy Eating" domain (Figure 11).
xii. Johnny navigates to the "Game Concept" tab and selects the Pac-Man game concept (Figure 12).

xiii. Johnny navigates to the "Persuasive Strategy" tab, where he selects the reward, competition, and suggestion strategies, along with their implementations (Figure 13).

xiv. Johnny then navigates to the "User Data" tab to choose demographic, gamer type, and persuasiveness data to collect (Figure 14).

xv. Upon completing the setup, Johnny clicks the "Save" button.

xvi. A confirmation pop-up displays Johnny's selections.

xvii. Johnny confirms his choices by clicking the "Accept" button (Figure 16).

xviii. The platform adds the new study, "Healthy Eating and Motivation" to the list of created game studies.

xix. Johnny clicks on the name of the study to access it.

xx. The platform opens the "View Study" page, allowing Johnny to manage and monitor the study's progress.

xxi. Johnny can provide the study link to participants by clicking the "Copy Study Link" button.

xxii. Later, Johnny logs in to check the progress of the study and monitor participant engagement.

xxiii. Upon completing the study duration, Johnny clicks 'End Study' to prompt participants to fill out surveys.

xxiv. After participants complete the surveys, Johnny downloads a CSV file containing the collected user data for analysis.

When a participant accesses the study link provided by the researcher, the platform initiates a search within the database to retrieve the specific study details associated with that link, collecting all the researcher's settings and configurations linked to the study. When the game is launched, this collected information is then used to determine the game settings and the elements. From framing types to persuasive strategies, each aspect is tailored based on the researcher's predefined criteria.

However, once the researcher decides to conclude the study, participants are no longer able to access the game. Instead, they are redirected to the study questionnaires, which they are prompted to complete, enabling the researcher to gather valuable insights into participants' perceptions and behaviours related to the persuasive gaming intervention.

In our platform's design, we adopted a tab-based page organization instead of the traditional sequential page-by-page layout used in the low-fidelity prototype. This strategic decision was informed by principles of Human-Computer Interaction (HCI) aimed at optimizing user navigation and interaction patterns[159]. By employing a tab-based interface, we aimed to streamline the user experience, enabling individuals to access different features of P-Gamer conveniently within a single screen. This approach minimizes the cognitive load associated with navigating through multiple pages, as users can easily switch between tabs to explore various aspects of the platform [159]. Furthermore, from an HCI perspective, this design choice aligns with the concept of reducing user effort and enhancing efficiency. By presenting all relevant options within immediate reach, users can easily locate and engage with the desired content without the disruption of navigating back and forth between different pages.

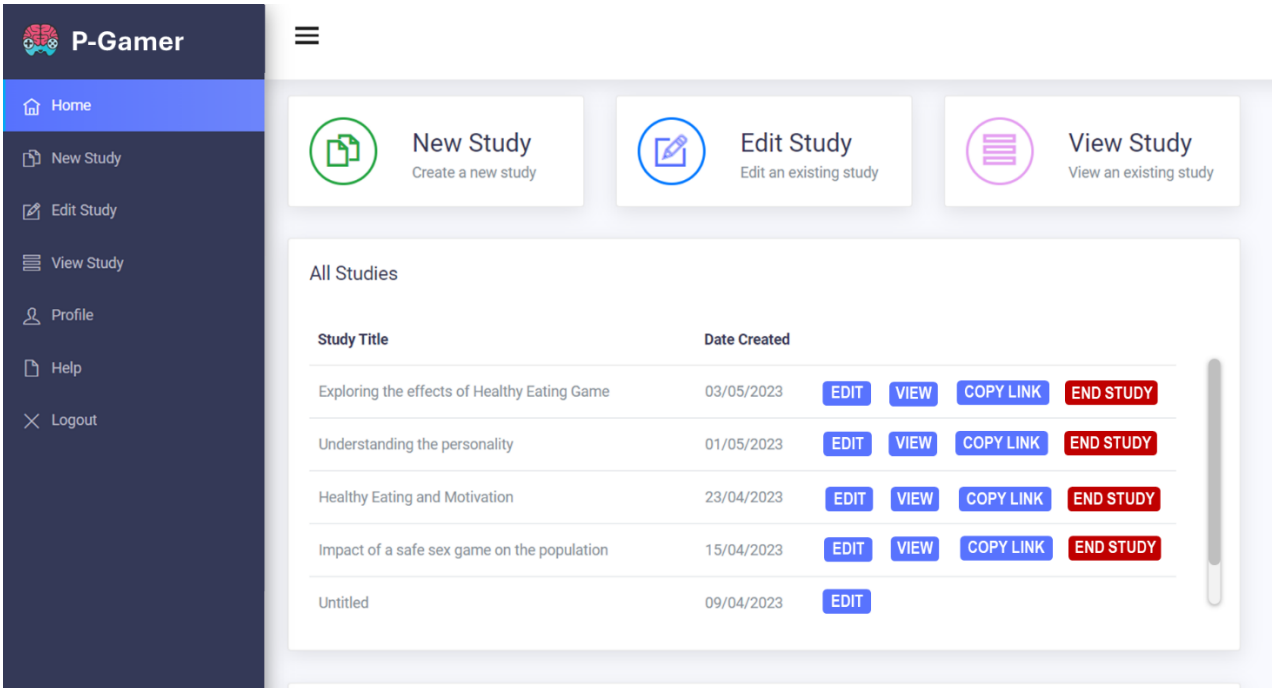

Figure 9 - Home Screen in P-Gamer

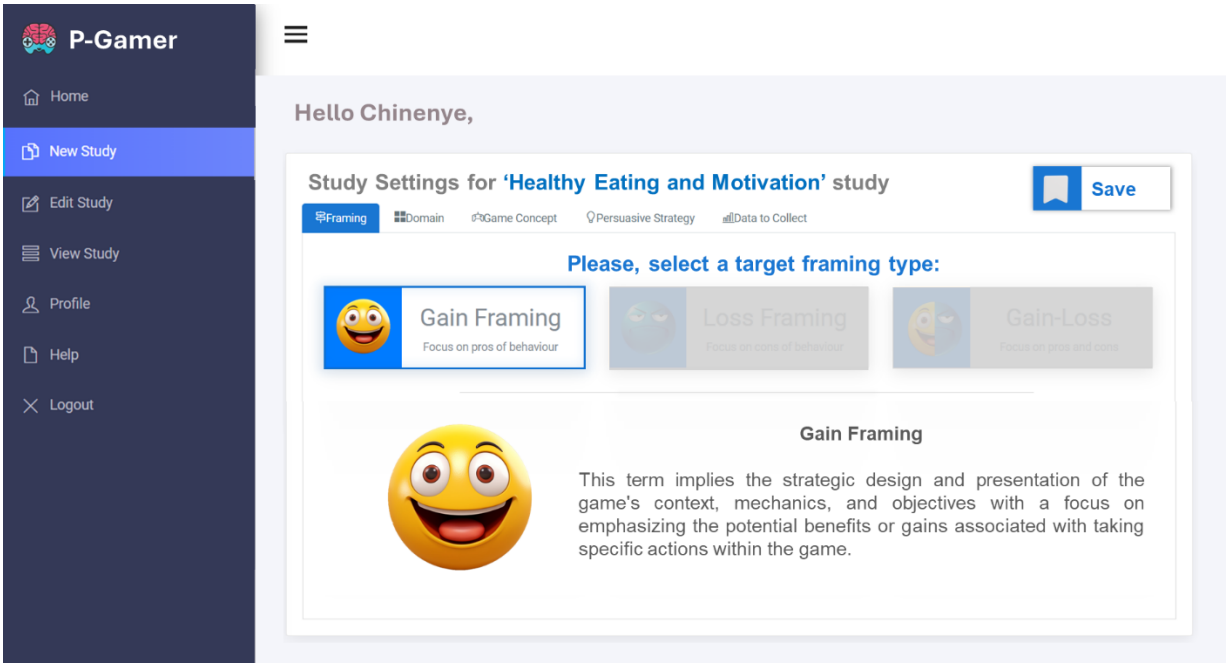

Figure 10 - Framing Type section in P-Gamer

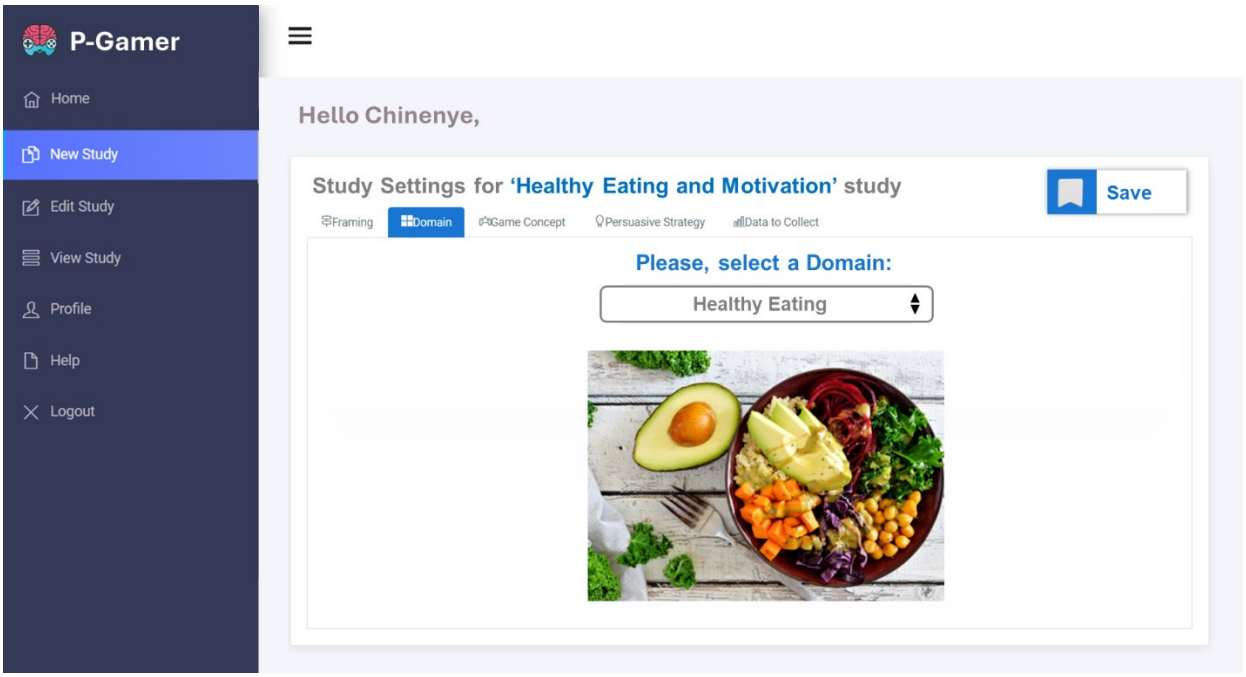

Figure 11 - Domain Section in P-Gamer

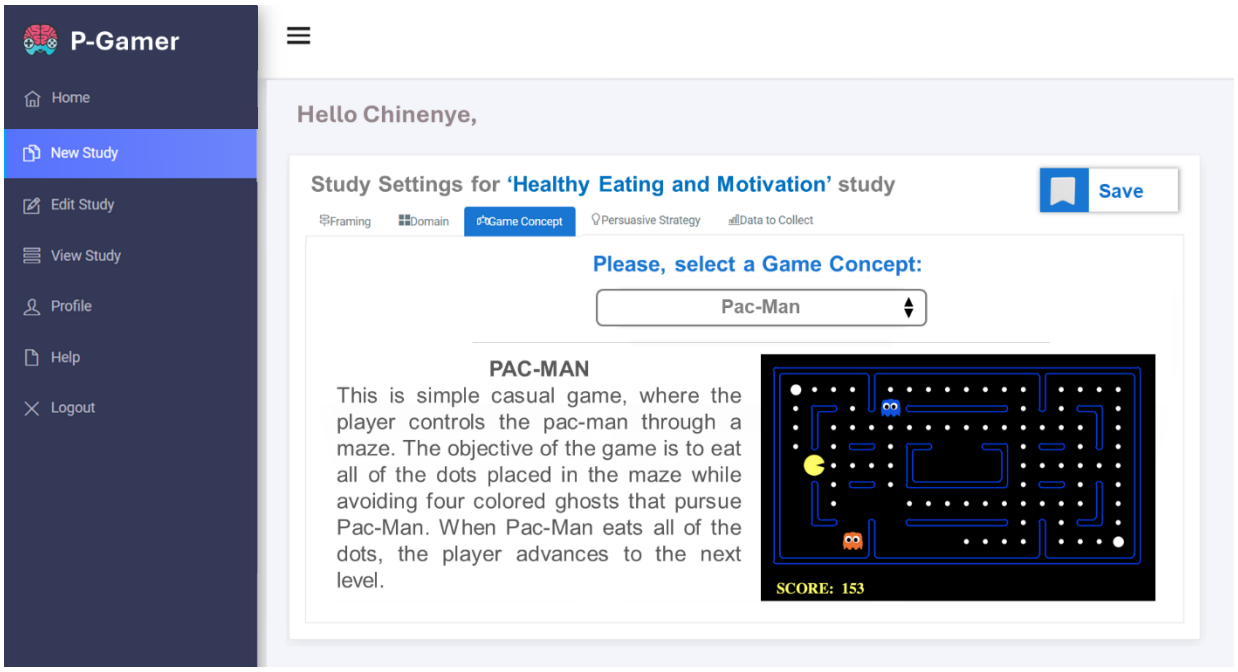

Figure 12 - Game Concept Section in P-Gamer

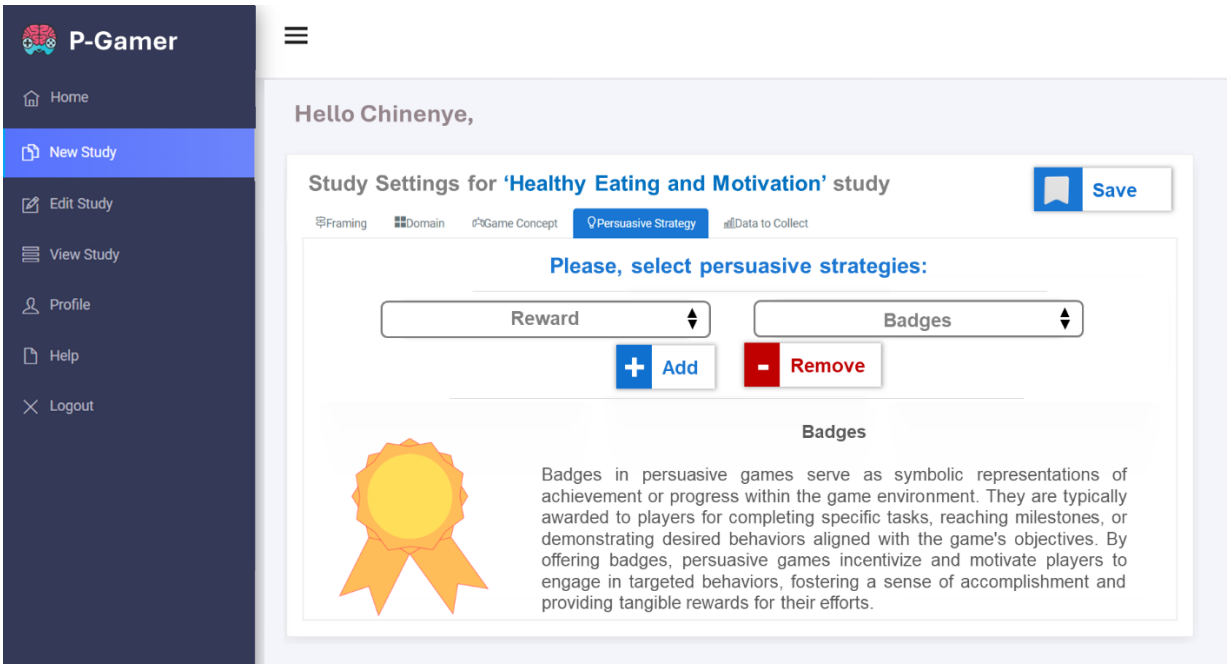

Figure 13 – Persuasive Strategy Section in P-Gamer

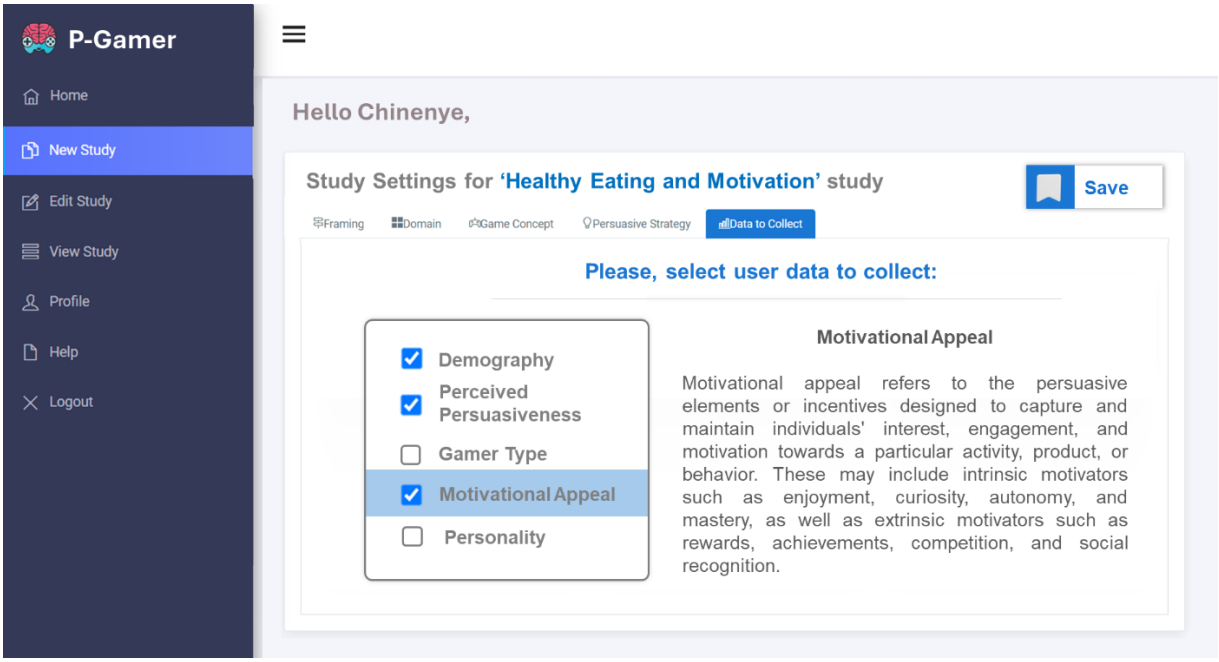

Figure 14 – User Data Section in P-Gamer

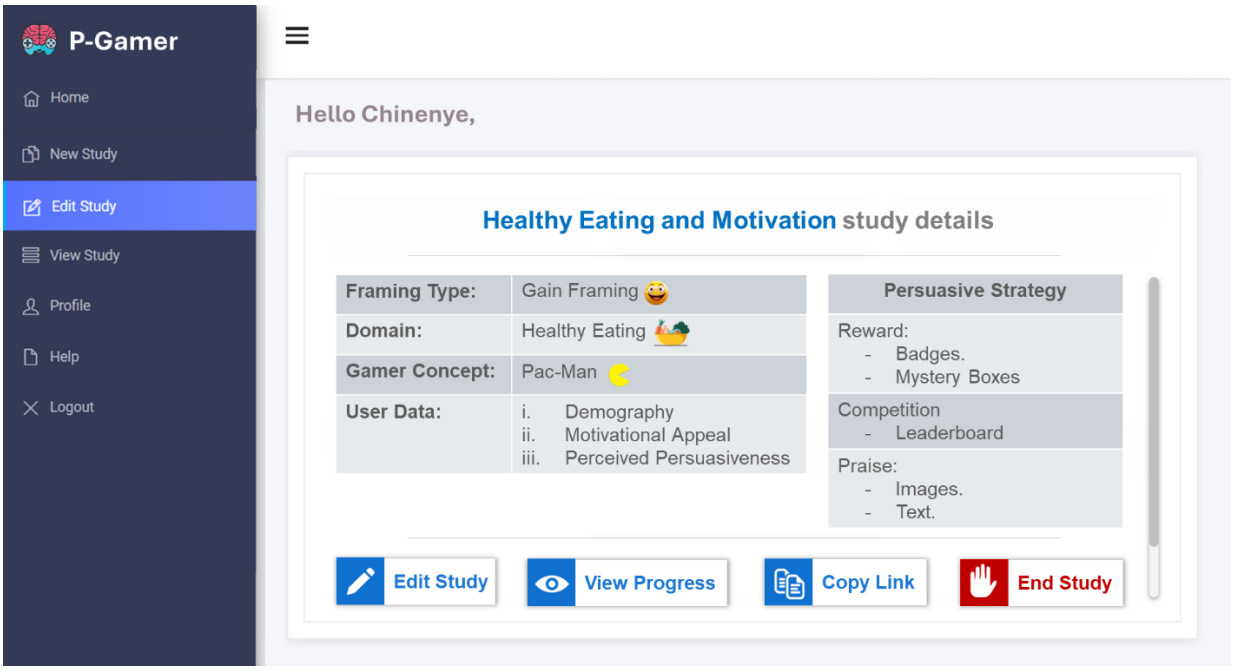

Figure 15 – View/Edit Section in P-Gamer

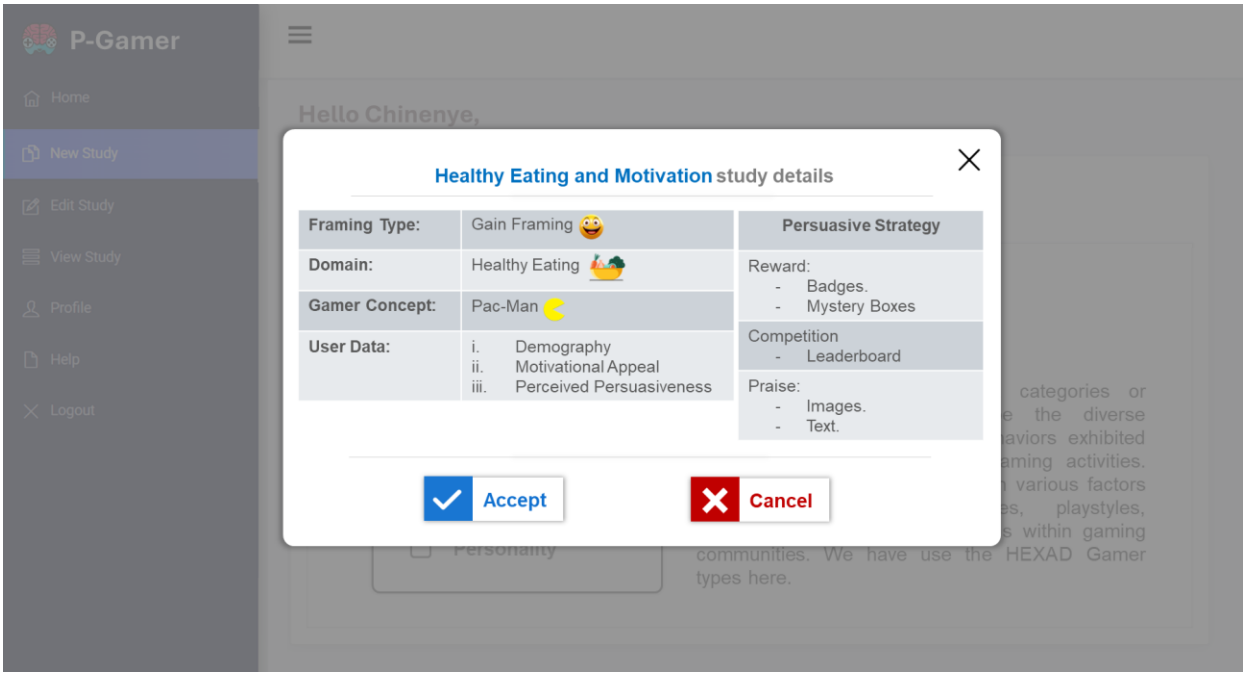

Figure 16 - Confirm Study screen in P-Gamer

3.6 Usability Study Design for the P-Gamer Platform

After the design of the P-Gamer platform, we carried out a study to understand the usability of the P-Gamer system. This study was carried out to answer the remaining two sub-research questions under RQ1:

RQ1d: How usable is the actual P-Gamer platform, in general?

RQ1e: How easy is it to use the major features of the P-Gamer platform?

This study involved the use of various study methods including observations, think-aloud and surveys. We recruited eight (8) participants, to evaluate the overall system and the major features of the system, based on the System Usability Scale (SUS) [91] and the Single Ease Question (SEQ) [168]. These evaluators were different from the ones used in the low-fidelity prototype stage, to eliminate any bias that may occur from previous knowledge.

Each participant was invited to an online session, we described a scenario of a persuasive game designer as in Section 3.5.1.1. and then invited them to create a persuasive game for that purpose. The participants were not instructed on what to do and how to go about developing the system. They were just given access to the P-Gamer platform for them to design a healthy eating persuasive game study, based on the scenario presented in the previous section. We observed them using a combination of observation techniques and the think-aloud method. After that, they filled out a survey where they rated the usability of the overall framework, using the SUS. Also, the Single Ease Question (SEQ) was used to measure the perceived task difficulty of the major sections of the P-Gamer framework.

Identical to the low fidelity prototype evaluation, we identified major features in the platform, namely: Target Framing section, Target Domain section, Game Concept section, Persuasive Strategy section, User Data section and the View/Edit Study (admin) section. After using each major section, the evaluators were asked to rate the ease of use using SEQ.

3.7 Results for the Usability of the P-Gamer Platform

To answer RQ1d – *How usable is the actual P-Gamer platform, in general?,* we calculated the SUS score of the system. We used the formula in equation (1), to calculate the overall SUS score of the system according to the ratings of the eight evaluators [178].

The P-Gamer platform had an overall SUS score of 90.63 which is above the excellent score of 85, according to Bangor et al. [16] [17] interpretation of the SUS scores, as shown in Figure 8. This implies that the system was perceived to be highly usable by persuasive system designers. This was also higher than the low-fidelity SUS score of 87.91.

To answer RQ1e – *How easy is it to use the major features of the P-Gamer low fidelity prototype?*, we ran one-sample t-tests on the SEQ scores for each major section in the platform. Our results showed that the mean values of the ratings of five sections were significantly higher than the nominal midpoint of 4. This implies that five of the sections of the platform were significantly easy to use. They are the Target Framing section ($t(7) = 16.80$, $p=.001$, mean=6.75), the Target Domain section ($t(7) = 23$, $p=.001$, mean=6.88), Game Concept section ($t(7) = 9.03$, $p=.001$, mean=6.38), the persuasive strategy section ($t(7) = 7.18$, $p=.001$, mean=6.25), user data section ($t(7) = 9.98$, $p=.001$, mean=6.63) and view/edit section Section ($t(7) = 7.20$, $p=.001$, mean=6.13).

Table 7 - T-Test result of the ease of use for each major feature of the P-Gamer Platform

P-Gamer Sections	t	df	Mean	SD	Sig
Target Framing	16.80	7	6.75	.463	.001
Target Domain	23.00	7	6.88	.354	.001
Game Concept	9.03	7	6.38	.744	.001
Persuasive Strategy	7.18	7	6.25	.886	.001
User Data	9.98	7	6.63	.744	.001
View/Edit Study	7.20	7	6.13	.835	.001

The SEQ ratings for the major section of this actual platform were higher than the ratings of the low-fidelity prototype version. This highlights the significance of an iterative user-centred design process when developing persuasive systems. Through iterative refinement based on user feedback and testing from the low-fidelity prototype, the platform was able to evolve from its initial prototype to a more polished and effective system. This iterative approach allows designers to

identify and address user needs, preferences, and pain points, ultimately resulting in a more engaging and persuasive user experience.

CHAPTER 4 Exploring the Impact of Application Domain on the Effectiveness of Persuasive Strategies

In the previous chapter, we explored the implementations and evaluation of the actual P-Gamer platform. Therefore, in this chapter, we explore the impact of application domains on behaviour change games across game framings, using games generated from the P-Gamer platform. This would address our second major research question - *RQ2: What is the impact of application domains on the perceived effectiveness of persuasive strategies across game framings?*

To answer this question, we present the results of a study on the effectiveness of four persuasive strategies (reward, competition, praise, and suggestion) across two distinct application domains (Healthy Eating and STD Awareness) across three game framings (gain-framing, loss framing and gain-loss framing). To properly explore this, we shall answer the following sub-research questions:

RQ2a: What is the perceived effectiveness of the persuasive strategies implemented in the Healthy Eating Domain for each framing type?

RQ2b: What is the perceived effectiveness of the persuasive strategies implemented in the STD awareness domain for each framing type?

RQ2c: Are there any differences in the perceived effectiveness of persuasive strategies in behaviour change games across application domains for each framing type?

4.1 Motivation for this Chapter

Persuasive games can be used in a wide range of application domains, from promoting healthy eating habits to raising awareness about sexually transmitted diseases (STDs). Each of these domains presents unique challenges and opportunities for persuasion, influenced by specific user motivations, cultural contexts, and the nature of the behaviour being targeted. For instance, strategies that are effective in encouraging individuals to adopt healthier eating habits may not necessarily translate well to efforts aimed at increasing STD awareness and prevention. By investigating the differences in the effectiveness of persuasive strategies across these distinct

application domains, we can gain valuable insights into the underlying mechanisms that drive behaviour change. This understanding can help in the design of more tailored and context-sensitive persuasive technologies, ultimately enhancing their effectiveness.

Furthermore, Game framing involves the intentional and strategic design of a game's context, mechanics, and objectives [156]. This concept encompasses three primary types of framing: gain-framing [92], loss-framing [171] and gain-loss-framing [94]. In the field of persuasive games, understanding the relationship between game framing and persuasive strategies is of paramount importance. Game framing not only lays the groundwork for the integration of persuasive game elements but also moulds players' perceptions of the game's purpose, context, and challenges. As a result, it can significantly impact the effectiveness of the embedded persuasive strategies aimed at motivating players toward specific behaviours or attitudes.

Therefore, exploring the impact of application domains on the effectiveness of persuasive strategies within framing types can contribute to the broader field of human-computer interaction (HCI) by highlighting the importance of contextual factors in the design and implementation of persuasive systems. Also, according to the Persuasive Systems Design (PSD) model [111], factors beyond user characteristics—such as usage contexts, including the problem domain the application is targeted at and framing type—may affect the effectiveness of persuasive strategies. This suggests that the context in which persuasive technology is applied can significantly influence how well it achieves its intended outcomes. Therefore, it is important to explore how the effectiveness of these strategies varies across different application domains for different game framings. This would help persuasive game designers to design more effective persuasive interventions tailored to specific contexts.

4.2 Method

In this section, we describe the game and measurement instruments used in our study, provide an overview of participant demographics, and detail our data analysis methods.

4.2.1 Game Design

To begin the study, using the P-Gamer platform, we generated a persuasive game and game study for each application domain (healthy eating and STD awareness) and each game framing, using the same parameters. Table 8 shows the parameters used. The following sections describe each game.

Table 8 - Parameters for the healthy eating and STD awareness game in the domain study

Parameters	**Values**
Game Concept	Pac-Man
Persuasive Strategies	Reward, Competition, Praise, Suggestion
User Data	Demography Data and Perceived Persuasiveness

This resulted in six different persuasive game study versions.

i. Pac-Man for Healthy Eating (Gain-Framed).
ii. Pac-Man for STD Prevention (Gain-Framed).
iii. Pac-Man for Healthy Eating (Loss-Framed).
iv. Pac-Man for STD Prevention (Loss-Framed).
v. Pac-Man for Healthy Eating (Gain-Loss-Framed).
vi. Pac-Man for STD Prevention (Gain-Loss-Framed).

We describe these six game versions in the following sections.

4.2.1.1 The Gain-Framed versions

Gain framing refers to the strategic design and presentation of the game's context, mechanics, and objectives with a focus on emphasizing the potential benefits or gains associated with taking specific actions within the game. We describe the two application domain versions in the following sections.

4.2.1.1.1 Pac-Man for Healthy Eating (Gain-Framed)

In this Pac-Man game version, the maze is filled with healthy food items like fruits, vegetables, and nuts, which are constantly moving around the maze. Pac-Man, the player-controlled character,

must consume all these healthy foods within a specified time limit. However, the healthy foods are not stationary; they actively try to avoid being eaten by Pac-Man. Pac-Man gains points for every healthy food item consumed. The challenge lies in Pac-Man's ability to navigate the maze efficiently, catching as many healthy foods as possible within the given time frame. The healthier the foods Pac-Man collects, the higher the score the player achieves. This gameplay design not only promotes healthy eating habits by encouraging the consumption of nutritious foods but also adds a time-bound challenge, making the game engaging and rewarding for players (see Figure 17).

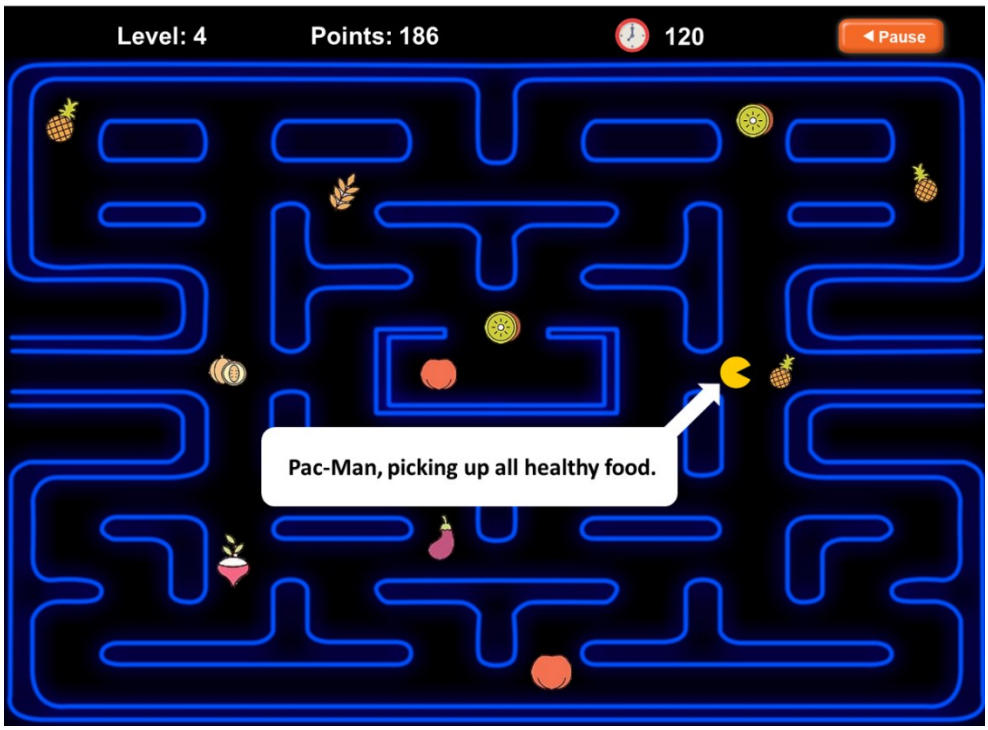

Figure 17 - Screenshot of the Pac-Man Healthy Eating version (Gain-Framed)

4.2.1.1.2 Pac-Man for STD Awareness (Gain-Framed)

Identical to the previous version, the maze is filled with game items representing safe behaviours relating to STDs (such as abstinence, use of condoms, and blood tests), which are constantly moving around the maze. Pac-Man, the player-controlled character, must catch all these game items within a specified time limit. However, these game items are not stationary; they actively try

to avoid being eaten by Pac-Man. Pac-Man gains points for every safe behaviour item catched. The challenge lies in Pac-Man's ability to navigate the maze efficiently, catching as many safe behaviour items as possible within the given time frame. The more safe behaviour game items Pac-Man collects, the higher the score the player achieves. This gameplay design not only promotes STD prevention by encouraging safe sexual behaviours but also adds a time-bound challenge, making the game engaging and rewarding for players (see Figure 18).

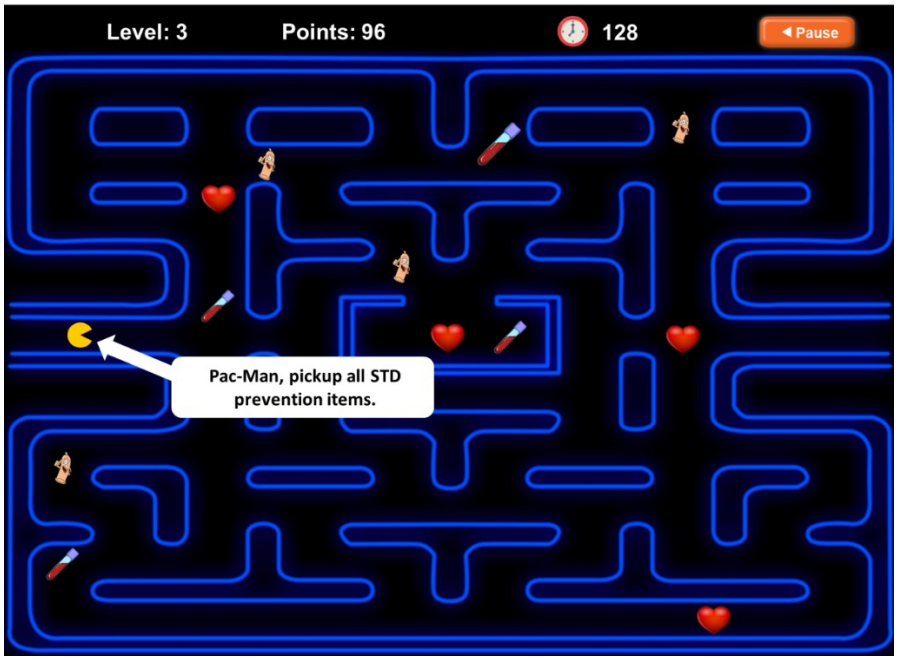

Figure 18 - Screenshot of the Pac-Man STD Awareness version (Gain-Framed)

4.2.1.2 The Loss-Framed versions

Loss framing involves integrating elements of game design and gameplay mechanics while emphasizing the potential losses or negative consequences associated with not engaging in desired behaviours or actions within the game. We describe the two application domain versions in the following sections.

4.2.1.2.1 Pac-Man for Healthy Eating (Loss-Framed)

In this version of Pac-Man, the game environment is filled with unhealthy food items like candies, chips, and soda cans. These unhealthy foods are constantly moving around the maze, actively

chasing after Pac-Man. The player's goal is to evade all these unhealthy foods within a specified time limit. If Pac-Man is caught by an unhealthy food item, the player's health decreases. The challenge for the player lies in manoeuvring Pac-Man skilfully to avoid being caught by the unhealthy foods. As time passes, the unhealthy foods become more aggressive and faster, making it increasingly difficult for Pac-Man to evade them. The player must use strategic movements and quick reflexes to survive and maintain Pac-Man's health throughout the game. This version of Pac-Man emphasizes the negative consequences of eating unhealthy foods. Players are motivated to make healthier choices by avoiding these items, showcasing how framing can impact player behaviour in a gaming context (see Figure 19).

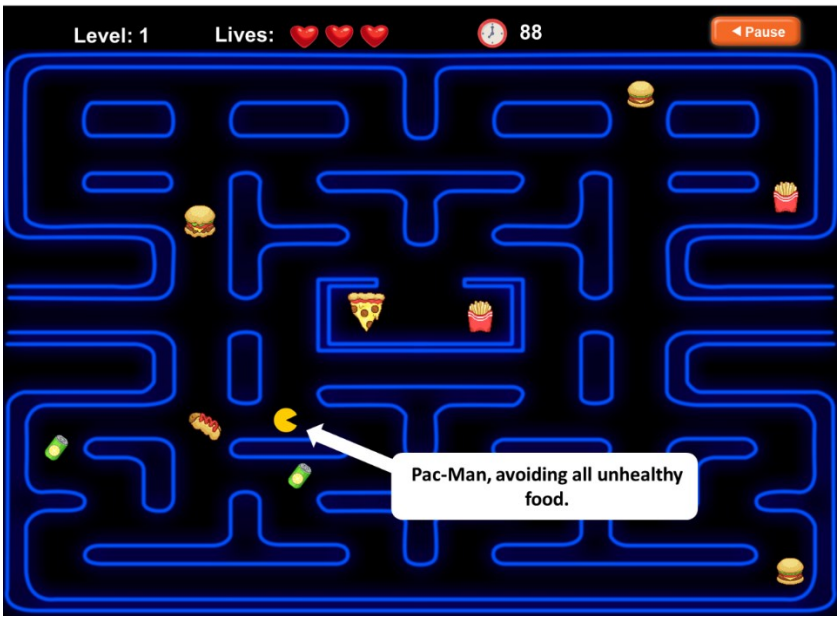

Figure 19 - Screenshot of the Pac-Man Healthy Eating version (Loss-Framed)

4.2.1.2.2 Pac-Man for STD Awareness (Loss-Framed)

Identical to the previous healthy eating version, the game environment is filled with game items representing risky behaviours (such as unprotected sex and the use of sharp objects) related to STDs. These game items are constantly moving around the maze, actively chasing after Pac-Man. The player's goal is to evade all these risky behaviour items within a specified time limit. If Pac-Man is caught by a risky behaviour item, the player's health decreases. The challenge for the player

lies in manoeuvring Pac-Man skilfully to avoid being caught. As time passes, the risky behaviour items become more aggressive and faster, making it increasingly difficult for Pac-Man to evade them. The player must use strategic movements and quick reflexes to survive and maintain Pac-Man's health throughout the game. This version of Pac-Man emphasizes the negative consequences of indulging in risky sexual behaviours. Players are motivated to make healthier choices by avoiding these items, showcasing how framing can impact player behaviour in a gaming context (see Figure 20).

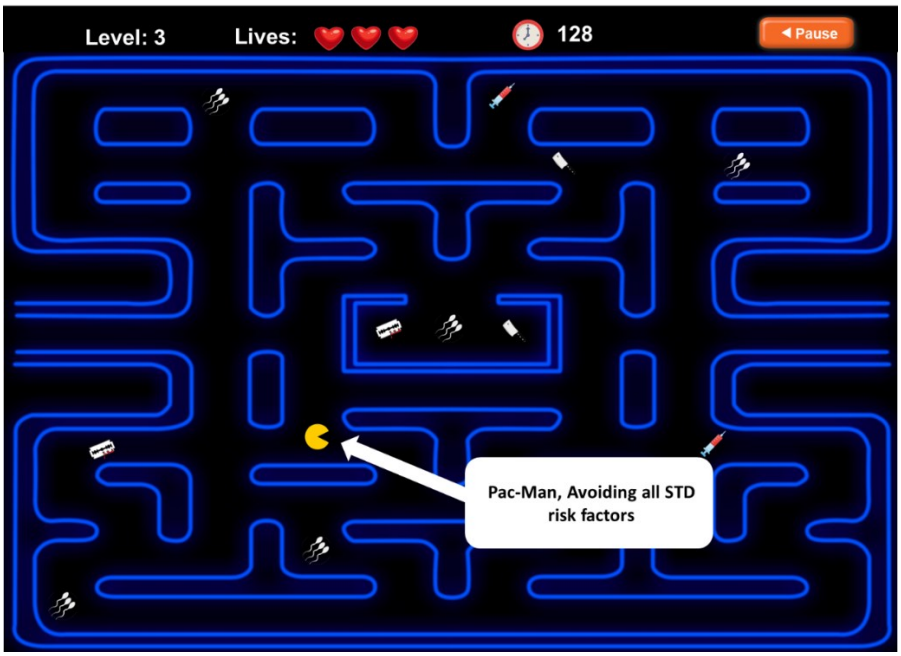

Figure 20 - Screenshot of the Pac-Man STD Awareness version (Loss-Framed)

4.2.1.3 The Gain-Loss-Framed versions

Gain-Loss framing emphasizes both the benefits and consequences of desired and undesired behaviours respectively. Specifically, it integrates elements of game design and gameplay mechanics that strategically highlight both the potential gains and losses associated with specific behaviours or choices within the game. We describe the two application domain versions in the following sections.

4.2.1.3.1 Pac-Man for Healthy Eating (Gain-Loss-Framed)

In this version of Pac-Man, the maze is populated with both healthy food items like fruits and vegetables and unhealthy food items like candies and junk food. Both types of food items are constantly moving around the maze. The player's objective is twofold: Pac-Man needs to consume all the healthy food items while simultaneously avoiding the unhealthy foods, all within a specified time limit. Players gain points for every healthy food item consumed, reflecting the positive aspect of the gain framing. However, if Pac-Man encounters an unhealthy food item, points are deducted, representing the loss aspect of the framing. The healthier items contribute positively to the player's score, while encounters with unhealthy items result in a penalty, reflecting the dual nature of gain-loss framing. This version of Pac-Man creates a dynamic and challenging gameplay experience where players must make quick decisions to balance collecting points through healthy food consumption and avoiding penalties by steering clear of unhealthy foods. It encourages players to prioritize healthy choices while penalizing interactions with unhealthy items, promoting a balanced and health-conscious gameplay approach. Figure 21 shows a screenshot of the game.

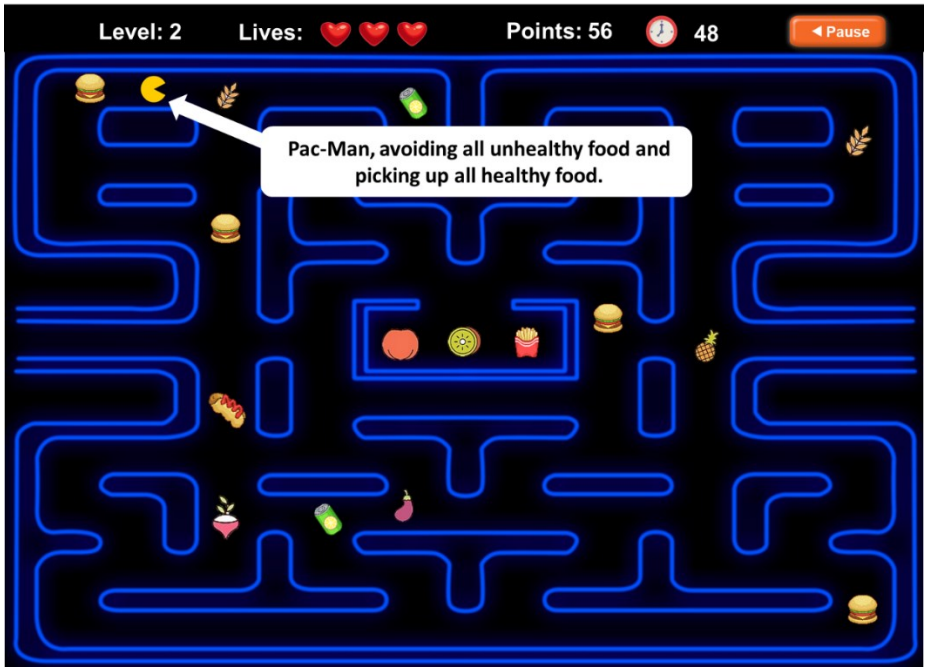

Figure 21 - Screenshot of the Pac-Man Healthy Eating version (Gain-Loss-Framed)

4.2.1.3.2 Pac-Man for STD Awareness (Gain-Loss-Framed)

This game version emphasizes both the benefits and consequences of safe and risk sexual behaviours. Specifically, it integrates elements of game design and gameplay mechanics that strategically highlight both the potential gains and losses associated with specific behaviours or choices within the game.

On the other hand, this STD-awareness version of Pac-Man maintains the same game mechanics as the Healthy eating version. The maze is populated with game items representing safe behaviours (such as abstinence, use of condoms, and blood tests) and risky behaviours (such as unprotected sex and the use of sharp objects) related to STD prevention. Both types of items are constantly moving around the maze. The player's objective is also twofold: Pac-Man needs to engage in all the safe behaviours while simultaneously avoiding the risky behaviours, all within a specified time limit. Players gain points for every safe behaviour item Pac-Man catch, reflecting the positive aspect of the gain framing. However, if Pac-Man encounters a risky behaviour item, points are deducted, representing the loss aspect of the framing. The safe behaviours contribute positively to

the player's score, while encounters with risky behaviours result in a penalty, reflecting the dual nature of gain-loss framing. This version of Pac-Man creates a dynamic and challenging gameplay experience where players must make quick decisions to balance collecting points through safe sexual behaviour engagement and avoiding penalties by steering clear of risky behaviours. The gain-loss framing encourages players to prioritize safe choices while avoiding interactions with risky behaviours, promoting a balanced and health-conscious gameplay approach. Figure 22 shows a screenshot of the game.

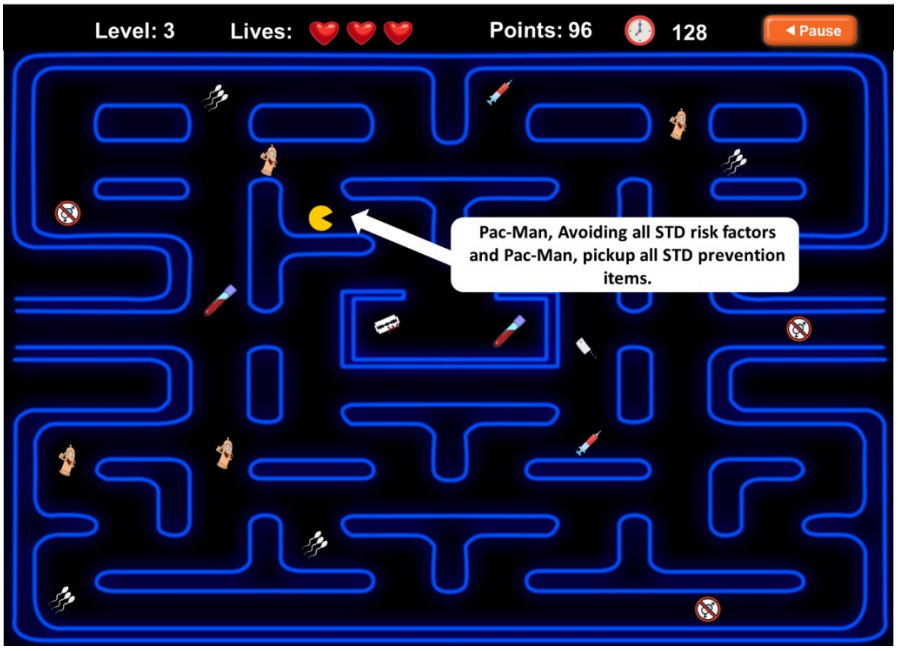

Figure 22 - Screenshot of the Pac-Man STD awareness version (Gain-Loss-Framed)

4.2.2 Measurement Instrument

In this study, our main objective was to investigate possible differences in the effectiveness of persuasive games and persuasive strategies across two application domains – healthy eating and STD awareness. To achieve this, we designed six versions of a persuasive game for healthy eating and STD awareness as described in the previous section. Then, we intentionally implemented four persuasive strategies from the PSD model in the same way. They are Reward, Competition, Suggestion, and Praise strategies. Table 9 shows the implementations of these strategies while

Figure 23, Figure 24, Figure 25, and Figure 26 are screenshots of some of the strategies. Other screenshots can be found in Appendix B.

Table 9 - Persuasive strategies and their implementations

Strategy	**Implementation**
Reward	Badges and points for completing in-game achievements. The badges were designed to align with the characteristics of each application domain. In the healthy eating version, players obtained the selector badge by collecting 50 healthy foods and avoiding 50 unhealthy foods (Figure 23), while in the STD awareness version, they obtained the selector badge by collecting 50 safe sexual behaviour items and avoiding 50 risky sexual behaviour items.
Competition	A leaderboard of points earned in-game. Players are ranked according to the points accumulated while playing the game (Figure 24).
Suggestion	Random pop-up tips about healthy eating or unhealthy eating practices and safe sexual behaviour or risky sexual behaviour items. The tips were also strategically tailored to match the characteristics of each application domain. In the healthy eating version, players received tips that both encouraged healthy eating and discouraged indulging in unhealthy options, striking a balance between positive and negative reinforcement, while in the STD awareness version, players received tips that both encouraged safe sexual behaviours and discouraged indulging in risky sexual behaviours (Figure 26).
Praise	Image and textual positive feedback for completing in-game achievements (Figure 25).

Figure 23 - Reward in the healthy eating version

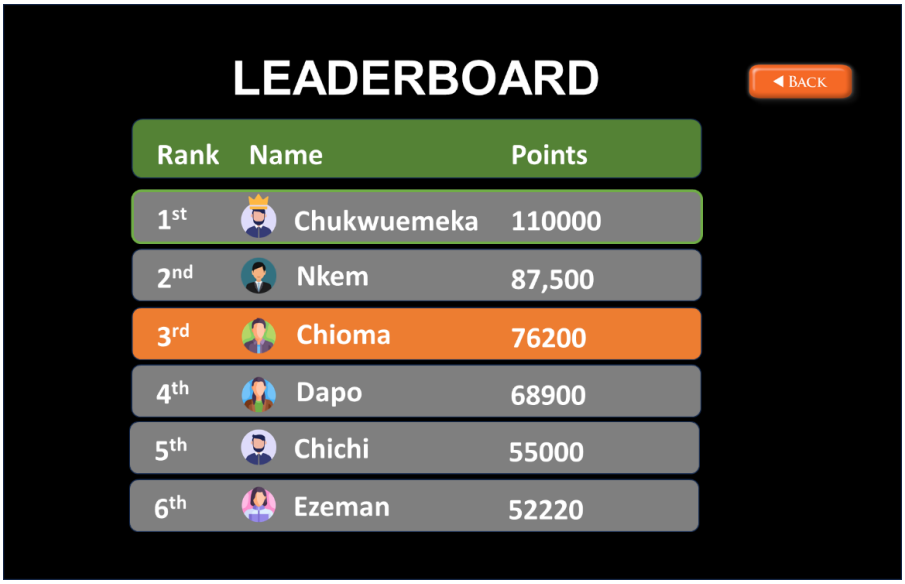

Figure 24 - Competition in the healthy eating and STD awareness version

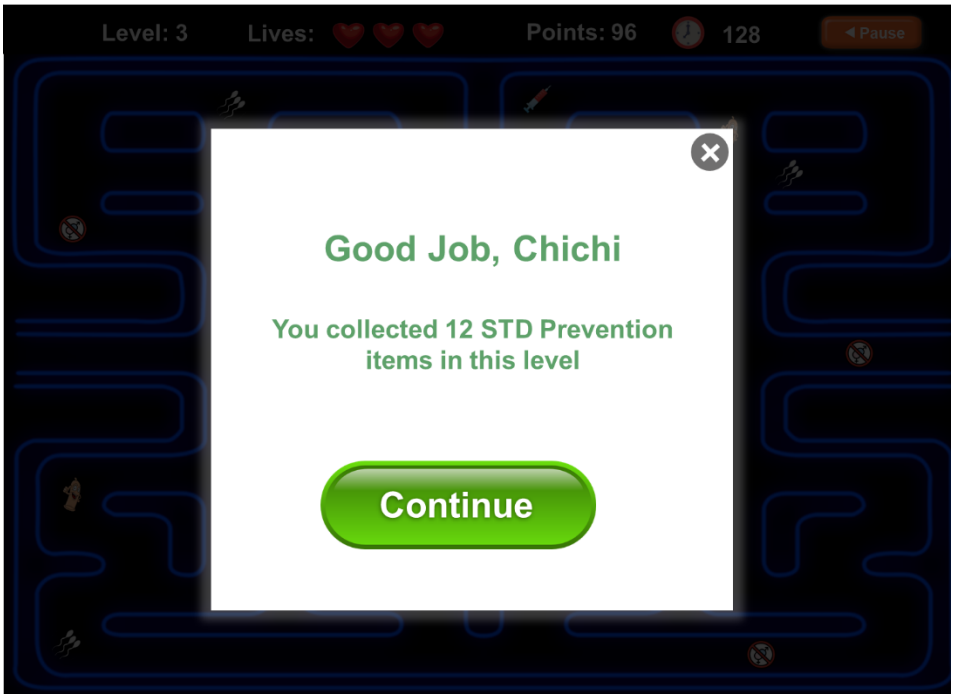

Figure 25 - Praise in the STD prevention version

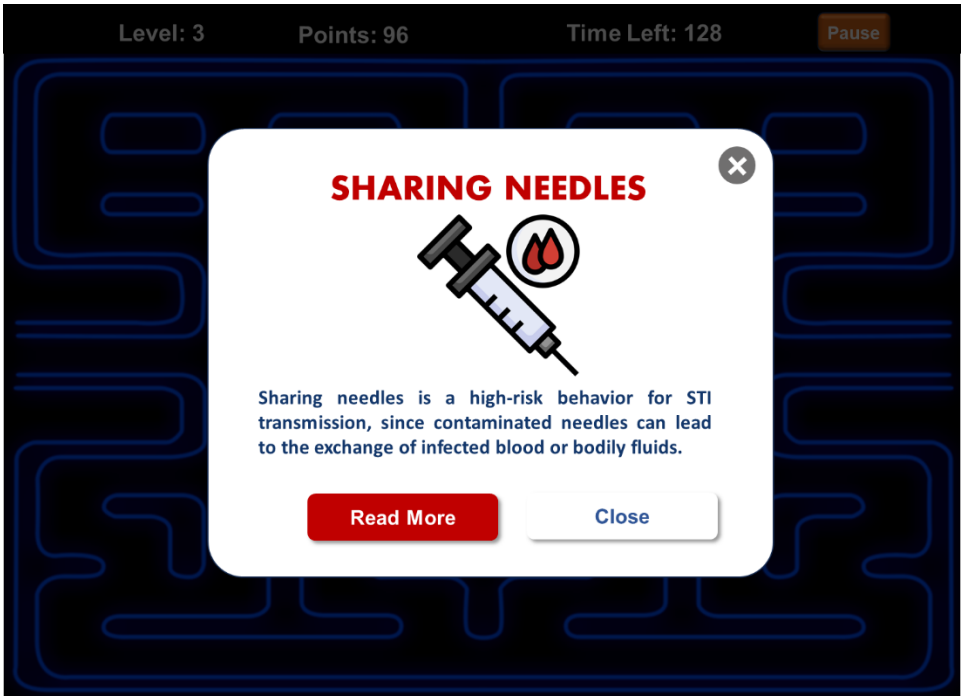

Figure 26 - Suggestion in the STD awareness version

After gameplay, to collect feedback from participants on the effectiveness of these strategies, the participants filled out a survey in the P-Gamer platform that asked users to rate their perceived

effectiveness of the strategies. The survey collected the perceived effectiveness of the overall game and the four persuasive strategies implemented in the game. The questionnaire was based on a scale adapted from Thomas et al. [162] and Drodz et al. [44]. The scale is a well-established measure used to evaluate the perceived persuasiveness of system features, and it has been utilized in various Human-Computer Interaction (HCI) and related research studies [44][29][118][121]. Table 10 shows the questions in the perceived persuasive scale for each application domain.

Table 10 – The adapted perceived persuasiveness scale questions for Healthy Eating and STD awareness

Healthy Eating	**STD Awareness**
Gain Framing	
i. "This feature/game would influence me to eat healthily." *ii. "This feature/game would convince me to eat healthily."* *iii. "This feature/game would be personally relevant to me."* *iv. "This feature/game would make me reconsider my eating habits."* *v. "The feature would make or motivate me to use the game."*	*i. This feature/game would influence me to practice safe sexual behaviours.* *ii. This feature/game would convince me to practice safe sexual behaviours.* *iii. This feature/game would be personally relevant for me.* *iv. This feature/game would make me reconsider my safe sexual behaviours.* *v. The feature would make me or motivate me to play the game*
Loss Framing	
i. This feature/game would influence me to stop eating unhealthily. *ii. This feature/game would convince me to stop eating unhealthily.* *iii. This feature/game would be personally relevant for me.* *iv. This feature/game would make me reconsider my eating habits.* *v. The feature would make or motivate me to play the game*	*i. "This feature/game would influence me to avoid risky sexual behaviours."* *ii. "This feature/game would convince me to avoid risky sexual behaviours."* *iii. "This feature/game would be personally relevant to me."* *iv. "This feature/game would make me reconsider my sexual behaviours."* *v. "The feature would make or motivate me to use the game."*
Gain-Loss Framing	

i. *This feature/game would influence me to eat healthily and stop eating unhealthily.* ii. *This feature/game would convince me to eat healthily and stop eating unhealthily.* iii. *This feature/game would be personally relevant for me.* iv. *This feature/game would make me reconsider my eating habits.* v. *The feature would make or motivate me to play the game*	i. *This feature/game would influence me to practice safe sexual behaviours and stop risky sexual behaviours.* ii. *This feature/game would convince me to practice safe sexual behaviours and stop risky sexual behaviours.* iii. *This feature/game would be personally relevant for me.* iv. *This feature/game would make me reconsider my safe sexual behaviours.* v. *The feature would make me or motivate me to play the game*

We measured these questions on a 7-point Likert scale ranging from "1 = Strongly disagree" to "7 = Strongly agree" for each strategy and the overall game.

4.2.3 Demographic Information

Initially, we recruited 409 participants for the study. They were allocated to different game framings as follows: 136 to gain-framing, 136 to loss-framing, and 137 to gain-loss-framing. Participants were instructed to engage with a game using the provided study link for at least 15 minutes a day over three consecutive days. Each participant received two study links for each domain within their assigned game framing, with the second link provided after completing the first. The order in which each participant experienced the two domain versions was randomized to mitigate potential order bias.

At the end of the gameplay duration for each domain study, participants completed a survey to capture their perceptions regarding the game's effectiveness and the four implemented persuasive strategies. After excluding incomplete responses, our analysis included 371 responses: 125 from gain-framing, 122 from loss-framing, and 124 from gain-loss-framing. Table 11 shows the demographic distribution of participants.

Table 11 – Demographic distribution of participants

Demographics	**Participants**
Gender	Female = 112 (30%), Male = 259 (70%)
Age Distribution	18-25 = 106 (29%), 26-35 = 189 (51%), 36-45 = 76 (20%)

Educational Background	Bachelor's = 255 (69%), Master's = 85 (23%), High school = 19 (5%), College diploma = 12 (3%).
Framing Type	Gain-framing = 125, Loss-framing = 122, and Gain-loss-framing = 124.

4.3 Data Analysis

Our primary research objective was to examine the persuasive game's effectiveness within and across the two domains. To achieve this, we conducted the following analysis:

i. *We used Cronbach's alpha to check the reliability of the responses. The reliability analysis showed that all the scales were internally consistent, with a Cronbach's alpha value of 0.8 which is an acceptable level of reliability* [32].
ii. *We conducted a one-sample t-test on the overall rating of each version of the game and their persuasive strategies, to verify the perceived effectiveness of each version.*
iii. *We conducted a repeated measure ANOVA on the mean ratings of each game version and each persuasive strategy to identify the significant difference in their effectiveness across the domains within each game framing. The analysis was conducted after validating the ANOVA assumptions, followed by pairwise comparison (using the Bonferroni method for adjusting degrees of freedom for multiple comparisons).*

4.4 Results

In this research, we present the results according to the research questions. We first explore the effectiveness of the persuasive strategies in each application domain. Then we compare the effectiveness of the persuasive strategies across the domain to identify any differences.

4.4.1 The effectiveness of the persuasive strategies in the Healthy Eating Version

To answer the research question – *RQ2a: What is the perceived effectiveness of the persuasive strategies implemented in the Healthy Eating Domain?* – we performed one-sample t-tests on the mean scores of user ratings for the healthy eating game version and the persuasive strategies. The tests were conducted with a reference to the neutral rating of 4 on a 7-point persuasiveness scale.

4.4.1.1 Gain Framing

Our findings revealed that the gain-framed healthy eating version was perceived as significantly effective ($t(124)= 31.85$, $p<.001$). Furthermore, the persuasive strategies deployed within the game were perceived as significantly effective, as illustrated in Table 12, with reward ($t(124)= 22.29$, $p<.001$), competition ($t(124)= 21.46$, $p<.001$), praise ($t(124)= 17.20$, $p<.001$), and suggestion ($t(124)= 17.36$, $p<.001$). This further shows a strong perceived effectiveness of the healthy eating version.

Table 12 - T-Test of the mean values of the Gain-Framed Healthy Eating game version and the persuasive strategies implemented. (All means were significant at p<.0001, test value = 4).

df = 124				
Strategies	**M**	**SD**	**t**	**p**
Reward	5.63	.819	22.29	.001
Competition	5.67	.868	21.46	.001
Praise	5.48	.962	17.20	.001
Suggestion	5.50	.967	17.36	.001
Overall	5.57	.551	31.85	.001
M = mean, df = degree of freedom, SD = Standard Deviation, t = t-value, p = p-value.				

4.4.1.2 Loss Framing

Our findings revealed that the loss-framed healthy eating version was perceived as significantly effective ($t(121)= 39.16$, $p<.001$). Furthermore, the persuasive strategies deployed within the game were perceived as significantly effective, as illustrated in Table 13, with reward ($t(121)= 33.98$, $p<.001$), competition ($t(121)= 31.55$, $p<.001$), praise ($t(121)= 18.85$, $p<.001$), and suggestion ($t(121)= 14.77$, $p<.001$). This further shows a strong perceived effectiveness of the healthy eating version.

Table 13 - T-Test of the mean values of the Loss-Framed Healthy Eating game version and the persuasive strategies implemented. (All means were significant at p<.0001, test value = 4).

df = 121				
Strategies	**M**	**SD**	**t**	**p**
Reward	5.98	.643	33.98	.001

Competition	6.00	.700	31.55	.001
Praise	5.53	.895	18.85	.001
Suggestion	5.50	1.120	14.77	.001
Overall	5.75	.494	39.16	.001
M = mean, df = degree of freedom, SD = Standard Deviation, t = t-value, p = p-value.				

4.4.1.3 Gain-Loss Framing

Our findings revealed that the gain-loss-framed healthy eating version was perceived as significantly effective ($t(123)=36.89$, $p<.001$). Furthermore, the persuasive strategies deployed within the game were perceived as significantly effective, as illustrated in Table 14, with reward ($t(123)= 26.59$, $p<.001$), competition ($t(123)= 27.04$, $p<.001$), praise ($t(123)= 17.96$, $p<.001$), and suggestion ($t(123)= 20.71$, $p<.001$). This further shows a strong perceived effectiveness of the healthy eating version.

Table 14 - T-Test of the mean values of the Gain-Loss-Framed Healthy Eating game version and the persuasive strategies implemented. (All means were significant at $p<.0001$, test value = 4).

df = 123				
Strategies	**M**	**SD**	**t**	**p**
Reward	6.04	0.852	26.59	.001
Competition	6.08	0.856	27.04	.001
Praise	5.48	0.915	17.96	.001
Suggestion	5.57	0.841	20.71	.001
Overall	5.79	0.540	36.89	.001
M = mean, df = degree of freedom, SD = Standard Deviation, t = t-value, p = p-value.				

4.4.2 The effectiveness of the persuasive strategies in the STD awareness version

To answer the research question – RQ2b: What is the perceived effectiveness of the persuasive strategies implemented in the STD awareness domain? – we also performed one-sample t-tests on the mean scores of user ratings for the STD awareness game versions and the persuasive strategies. The tests were conducted with a reference to the neutral rating of 4 on a 7-point persuasiveness scale.

4.4.2.1 Gain Framing

Our findings revealed that the gain-framed STD awareness version was perceived as significantly effective ($t(124)= 24.81$, $p<.001$). Furthermore, the persuasive strategies deployed within the game were perceived as significantly effective, as illustrated in Table 15, with reward ($t(124)= 16.07$, $p<.001$), competition ($t(124)= 14.02$, $p<.001$), praise ($t(124)= 12.06$, $p<.001$), and suggestion ($t(124)= 18.81$, $p<.001$). This further shows a strong perceived effectiveness of the STD awareness version.

Table 15 - T-Test of the mean values of the Gain-Framed STD awareness game version and the persuasive strategies implemented. (All means were significant at $p<.0001$, test value = 4).

df = 124				
Strategies	**M**	**SD**	**t**	**p**
Reward	5.18	.818	16.07	.001
Competition	5.23	.984	14.02	.001
Praise	5.07	.992	12.06	.001
Suggestion	5.55	.922	18.81	.001
Overall	5.26	.567	24.81	.001
M = mean, df = degree of freedom, SD = Standard Deviation, t = t-value, p = p-value.				

4.4.2.2 Loss Framing

Our findings revealed that the loss-framed STD awareness version was perceived as significantly effective ($t(121)= 40.72$, $p<.001$). Furthermore, the persuasive strategies deployed within the game were perceived as significantly effective, as illustrated in Table 16, with reward ($t(121)= 23.98$, $p<.001$), competition ($t(121)= 21.50$, $p<.001$), praise ($t(121)= 13.84$, $p<.001$), and suggestion ($t(121)= 17.02$, $p<.001$). This further shows a strong perceived effectiveness of the STD awareness version.

Table 16 - T-Test of the mean values of the Loss-Framed STD awareness game version and the persuasive strategies implemented. (All means were significant at $p<.0001$, test value = 4).

df = 121				
Strategies	**M**	**SD**	**t**	**p**

Reward	6.12	.654	23.98	.001
Competition	6.21	.540	21.50	.001
Praise	5.43	.902	13.84	.001
Suggestion	5.64	1.062	17.02	.001
Overall	5.85	.501	40.72	.001
M = mean, df = degree of freedom, SD = Standard Deviation, t = t-value, p = p-value.				

4.4.2.3 Gain-Loss Framing

Our findings revealed that the gain-loss-framed STD awareness version was perceived as significantly effective ($t(123)= 32.52$, $p<.001$). Furthermore, the persuasive strategies deployed within the game were perceived as significantly effective, as illustrated in Table 17, with reward ($t(123)= 23.99$, $p<.001$), competition ($t(123)= 23.27$, $p<.001$), praise ($t(123)= 18.09$, $p<.001$), and suggestion ($t(123)= 18.80$, $p<.001$). This further shows a strong perceived effectiveness of the STD awareness version.

Table 17 - T-Test of the mean values of the Gain-Loss-Framed STD awareness game version and the persuasive strategies implemented. (All means were significant at p<.0001, test value = 4).

df = 123				
Strategies	**M**	**SD**	**t**	**p**
Reward	5.91	.884	23.99	.001
Competition	5.98	.945	22.53	.001
Praise	5.42	.871	18.09	.001
Suggestion	5.53	.908	18.80	.001
Overall	5.71	.595	32.52	.001
M = mean, df = degree of freedom, SD = Standard Deviation, t = t-value, p = p-value.				

4.4.3 The differences in the effectiveness of persuasive strategies across domains

To address the research question – *RQ2c: Are there any differences in the perceived effectiveness of persuasive strategies in behaviour change games across application domains?* – we conducted repeated measure ANOVAs on the mean ratings of the overall game versions and the four

persuasive strategies (Reward, Competition, Praise, and Suggestion) across two domains: healthy eating and STD awareness. This analysis was performed generally and for each framing type, using the application domain as the within-subject factor.

4.4.3.1 Application Domain Differences Overall

To examine the overall ratings across the two domains generally, we combined the results from the three framing types within each domain and compared them across the two domains. Our analysis revealed a significant main effect of domains ($F(1,370) = 28.343$, $p < .001$, $\eta^2 = 0.071$). This indicates a significant impact of the application domain on the overall perceived effectiveness across the two domains. Specifically, our post-hoc pairwise comparisons revealed that participants rated the healthy eating version significantly higher in perceived effectiveness compared to the STD awareness version in this framing type, as shown in Figure 27.

Regarding the persuasive strategies, we found significant main effects of domains for the reward ($F(1,370) = 20.617$, $p < .001$, $\eta^2 = 0.053$), competition ($F(1,370) = 13.593$, $p < .001$, $\eta^2 = 0.035$), and praise ($F(1,370) = 24.496$, $p < .001$, $\eta^2 = 0.062$) strategies across the domains. This suggests that the perceived effectiveness of these strategies varies depending on the application domain. Post-hoc pairwise comparisons further indicated that participants favoured the reward and competition strategies in the healthy eating version over the STD awareness version.

On the other hand, although the suggestion strategy emerged to be more effective for the STD awareness domain than healthy eating, however, this difference is not significant. Hence, there was no significant main effect of the suggestion strategy on the domains across the two versions ($F(1,370) = 1.711$, $p < .192$, $\eta^2 = 0.005$). This implies that the perceived effectiveness of these strategies may not vary significantly between the application domains, suggesting that this strategy can be implemented similarly across different domains.

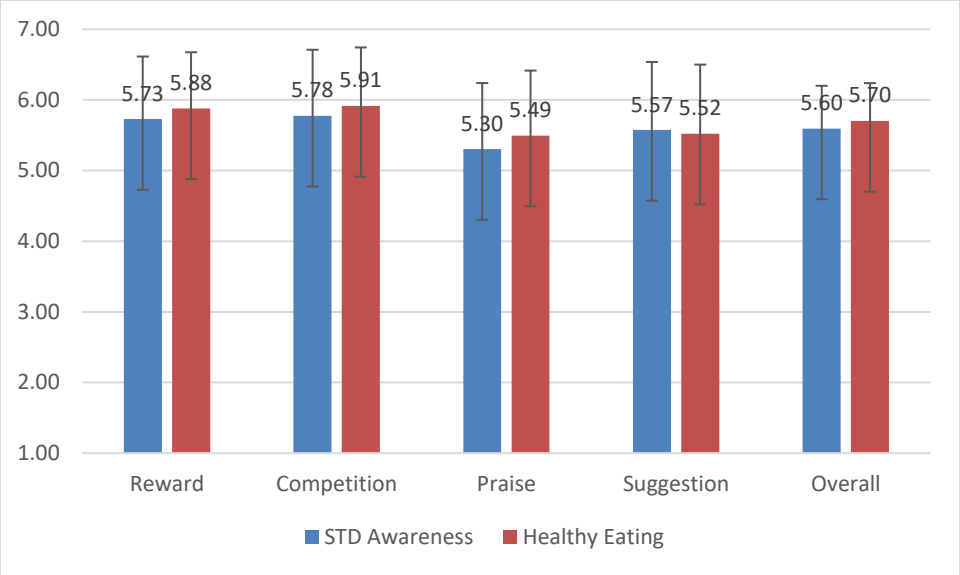

Figure 27 - Bar Chart comparing the combined effectiveness of strategies across the healthy eating and STD awareness domains

4.4.3.2 Application Domain Differences in Gain Framing

For the overall ratings of the two game versions in Gain Framing, the analysis demonstrated a significant main effect of domains in this framing type ($F(1,124) = 99.889$, $p < .001$, $\eta^2 = 0.446$). This indicates a significant impact of the application domain on the overall perceived effectiveness of the gain-framed game across the two domains. Post-hoc pairwise comparisons revealed that participants rated the healthy eating version significantly higher in perceived effectiveness compared to the STD awareness version in this framing type, as shown in Figure 28.

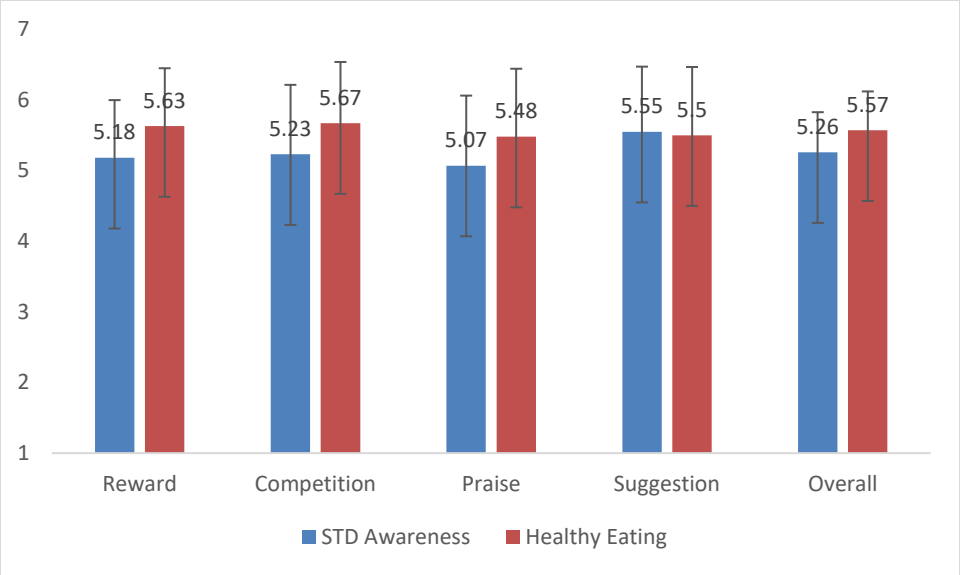

Figure 28 - Bar Chart comparing the effectiveness of strategies across the healthy eating and STD awareness domains for the Gain Framing

Regarding the persuasive strategies, the analysis showed significant main effects of domains for the reward ($F(1,124) = 87.022$, $p < .001$, $\eta^2 = 0.412$), competition ($F(1,124) = 40.441$, $p < .001$, $\eta^2 = 0.246$), and praise ($F(1,124) = 39.170$, $p < .001$, $\eta^2 = 0.240$) strategies across the domains. This suggests that the perceived effectiveness of these strategies varies depending on the application domain. Post-hoc pairwise comparisons further indicated that participants favoured the reward and competition strategies in the healthy eating version over the STD awareness version.

On the other hand, although the suggestion strategy emerged to be more effective for the STD domain than the healthy eating, however, this difference is not significant. Hence, there was no significant main effect of suggestions strategy on the domains across the two versions in the gain-framing type ($F(1,124) = 0.531$, $p = .467$, $\eta^2 = 0.004$). This implies that the perceived effectiveness of these strategies may not vary significantly between the application domains, suggesting that this strategy can be implemented similarly across different domains.

4.4.3.3 Application Domain Differences in Loss Framing

For the overall ratings of the two game versions in Loss-Framing, the analysis demonstrated a significant main effect of domains in this framing type ($F(1,121) = 9.338$, $p < .001$, $\eta^2 = 0.07$). This indicates a significant impact of the application domain on the overall perceived effectiveness

of the loss-framed game across the two domains. Post-hoc pairwise comparisons revealed that participants rated the STD awareness version significantly higher in perceived effectiveness compared to the healthy eating version in this framing type, as shown in Figure 29.

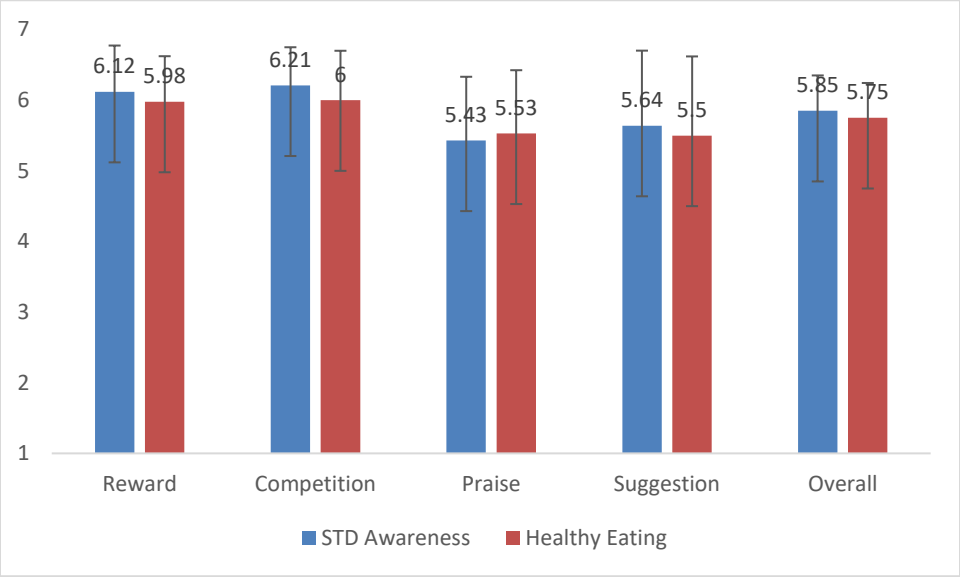

Figure 29 - Bar Chart comparing the effectiveness of strategies across the healthy eating and STD awareness domains for the Loss Framing

Regarding the persuasive strategies, the analysis showed significant main effects of domains for the reward ($F(1,121) = 5.871$, $p = .017$, $\eta^2 = 0.046$) and competition ($F(1,121) = 14.974$, $p < .001$, $\eta^2 = 0.110$) strategies across the domains. This suggests that the perceived effectiveness of these strategies varies depending on the application domain. Post-hoc pairwise comparisons further indicated that participants favoured the reward and competition strategies in the STD awareness version over the healthy eating version.

On the other hand, the praise ($F(1,121) = 2.187$, $p = .142$, $\eta^2 = 0.018$) and suggestion ($F(1,121) = 3.545$, $p = .062$, $\eta^2 = 0.028$) strategies showed no significant main effects of domains across the two versions in the loss-framing type. This implies that the perceived effectiveness of these strategies may not vary between the application domains, suggesting that these strategies can be implemented similarly across different domains for loss-framing.

4.4.3.4 *Application Domain Differences in Gain-Loss Framing*

For the overall ratings of the two game versions in Gain-Loss Framing, the analysis demonstrated a significant main effect of domains across the two versions ($F(1,123) = 10.259$, $p = .002$, $\eta^2 = 0.077$). This indicates a significant impact of the application domain on the overall perceived effectiveness of the gain-loss-framed game across the two domains. Post-hoc pairwise comparisons revealed that participants rated the healthy eating version significantly higher in perceived effectiveness compared to the STD awareness version, as shown in Figure 30.

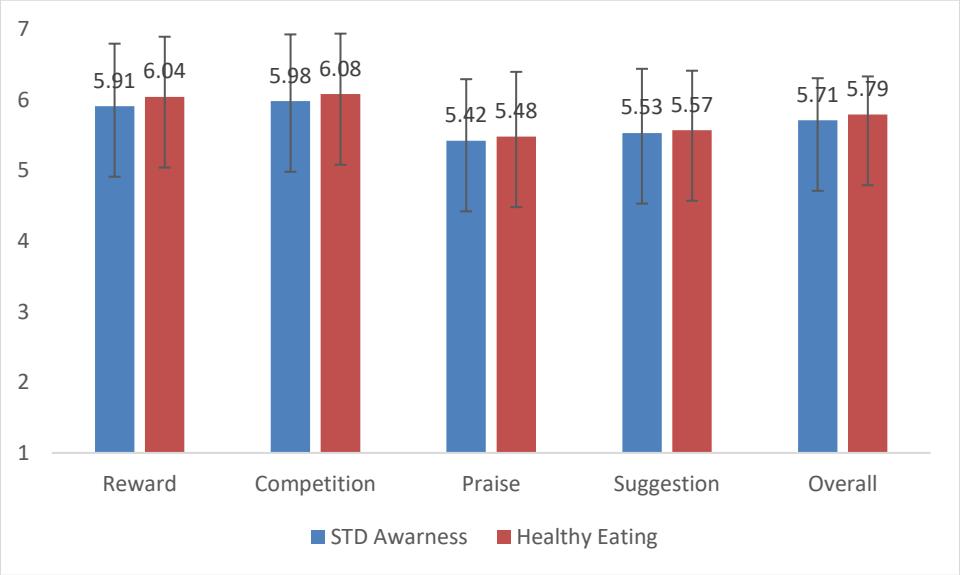

Figure 30 - Bar Chart comparing the effectiveness of strategies across the healthy eating and STD awareness domains for the Gain-Loss Framing

Regarding the persuasive strategies, the analysis showed significant main effects of game framing across the two domains for both the reward ($F(1,123) = 5.193$, $p = .024$, $\eta^2 = 0.041$) and competition ($F(1,123) = 10.057$, $p = .002$, $\eta^2 = 0.076$) strategies across the domains. This suggests that the perceived effectiveness of these strategies varies depending on the application domain. Post-hoc pairwise comparisons further indicated that participants favoured the reward and competition strategies in the healthy eating version over the STD awareness version.

On the other hand, the praise ($F(1,123) = 0.892$, $p = .347$, $\eta^2 = 0.007$) and suggestion ($F(1,123) = 0.230$, $p = .632$, $\eta^2 = 0.002$) strategies showed no significant main effects of game framing across the domains. This implies that the perceived effectiveness of these strategies does not vary between

the application domains, suggesting that these strategies can be implemented similarly across different domains.

In summary, the persuasive game in the healthy eating domain was generally significantly higher in perceived effectiveness compared to the STD awareness version. Also, participants generally favoured reward, competition, and praise strategies in the healthy eating game. These findings suggest that these strategies are more impactful when applied to health-related behaviours such as eating habits. In contrast, the suggestion strategy did not show a significant difference between the two domains, implying it can be equally effective across different contexts.

Interestingly, in the loss-framed games, the STD awareness version was perceived as more effective than the healthy eating version. Also, participants preferred reward and competition strategies in the STD awareness domain, indicating these strategies are more effective in contexts involving risk and preventive behaviours. However, praise and suggestion strategies did not differ significantly between domains, suggesting these approaches might have a more universal appeal regardless of the domain's nature for loss-framing.

Overall, our findings highlight the importance of tailoring persuasive strategies to the specific application domain. While reward and competition strategies are effective across both domains, their impact varies significantly. The universal effectiveness of the suggestion strategy suggests its broader applicability, making it a versatile tool in persuasive system design. These insights are crucial for developers of serious games and other persuasive technologies, as they underline the necessity of domain-specific customization to maximize the effectiveness of behaviour change interventions.

We discuss these results in detail in Section 7.1 of this thesis.

CHAPTER 5 Exploring the Impact of Game Framing and the Effectiveness of Persuasive Strategies and their Motivational Appeal

In the previous chapter, we have shown that application domains have a significant impact on the effectiveness of persuasive strategies in behaviour change games. In this chapter, we further explore the impact of game framing on persuasive strategies and their motivational appeal. This would address two of our major research questions: *RQ3 – What is the impact of game framing on the effectiveness of persuasive strategies?*[4] and *RQ4 – What is the relationship between the effectiveness of the persuasive strategies and their motivational appeal across game framings?*[5] Specifically, we present the research methodology and results of the impact of three game framing types on the effectiveness of four persuasive strategies and their motivational appeal in a healthy eating behaviour change game. We answer the following sub-research questions:

RQ3a: How does game framing impact the perceived effectiveness of persuasive games?

RQ3b: Comparatively, what is the perceived effectiveness of persuasive strategies across game framings?

RQ4a: What is the relationship between the motivational appeal of persuasive strategies and their effectiveness within each game framing?

RQ4b: Comparatively, what are the differences in the relationships between the motivational appeal of persuasive strategies and their effectiveness in behaviour change games across the three game framing versions?

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[4] Accepted for Publishing in **Chinenye Ndulue** and Rita Orji, The Impact of Persuasive Framing on the Perceived Effectiveness of a Game for Behaviour Change. International Journal of Human–Computer Interaction.

[5] First stage of review in **Chinenye Ndulue** and Rita Orji, Exploring the Impact of Game Framing on the Motivational Appeal of Persuasive Strategies and their Effectiveness in Behaviour Change Games. – Submitted to the Behaviour & Information Technology journal.

5.1 Motivation for this work

In recent years, persuasive games have gained recognition as powerful tools for promoting behaviour change and influencing attitudes across various domains of life. Rooted in the broader category of serious games and games for change, persuasive games stand out for their dual purpose: entertaining gameplay coupled with persuasive intent [27]. They harness the engaging qualities of games to nudge players toward specific behaviours and attitudes [18]. The potential of persuasive games lies in their ability to captivate and motivate players, while effectively conveying persuasive messages [67].

Persuasive games have been proven to be effective over the years in various domains such as Disease Prevention [28][175][108], Healthy Nutrition [78][93][119] and Physical Activity [33][31][42]. However, the effectiveness of these games is impacted by a variety of factors. For example, research has shown that the effectiveness of persuasive games can be impacted by factors such as age groups [166][132], gender groups [132][167], gamer types [123], gamification user type [122], and personality types [125][11]. These factors are mostly individual differences-related factors. While the effect of individual differences-related factors has gained some attention, the effect of other contextual factors such as persuasive game design-related contextual factors on the effectiveness of persuasive games has hardly been explored. An important game-context or game-design-related factor that can influence the effectiveness of persuasive games is game framing. Game framing refers to the deliberate and strategic design of a game's context, mechanics, and objectives [156]. Generally, there are three main types of framing: gain-framing [92], loss-framing [171] and gain-loss-framing[49, 94]. In the field of persuasive games, where engagement meets behaviour change, the relationship between game framing and persuasive strategies is paramount. Game framing not only establishes the foundation for integrating persuasive game elements but also shapes players' perceptions of the game's purpose, context, and challenges. Consequently, it may influence the effectiveness of the persuasive strategies that are embedded within the game to motivate players toward specific behaviours or attitudes.

Therefore, it is research-worthy to explore the relationships between game framing, persuasive strategies and persuasive game effectiveness This exploration will enable designers and researchers to fully harness the persuasive potential of behaviour change games.

Furthermore, another factor that can impact the effectiveness of persuasive games is the motivational appeal of the persuasive strategies implemented in them [130]. The ARCS motivational appeal model[86] is based on a combination of four motivational dimensions namely attention (A), relevance (R), confidence (C), and satisfaction (S). These dimensions represent specific aspects of motivation that can determine how appealing persuasive game features can be. Therefore, since the framing of a game may impact players' reception of persuasive games, it is important to explore the motivational appeal of these persuasive strategies across the different game framing types. These results will enable designers and researchers to design their persuasive games to harness the full potential of these strategies when developing games for behaviour change with different framings.

5.2 Method

In this section, we describe demographics and the measurement instrument used in our study, provide an overview of participant demographics, and detail our data analysis methods.

5.2.1 Game Design

To investigate the impact of game framing on the effectiveness of persuasive games, using the P-Gamer platform, we designed three versions of a Pac-Man-style game for Healthy eating. Each version corresponds to the three different persuasive game framing types. We present each of these framings and their implementation in detail in the following sections.

5.2.1.1 Persuasive Gain game framing (GF):

This term implies the strategic design and presentation of the game's context, mechanics, and objectives with a focus on emphasizing the potential benefits or gains associated with taking specific actions within the game.

In this Pac-Man game version, the maze is filled with healthy food items like fruits, vegetables, and nuts, which are constantly moving around the maze. Pac-Man, the player-controlled character, must consume all these healthy foods within a specified time limit. However, the healthy foods are not stationary; they actively try to avoid being eaten by Pac-Man. Pac-Man gains points for every healthy food item consumed. The challenge lies in Pac-Man's ability to navigate the maze efficiently, catching as many healthy foods as possible within the given time frame. The healthier foods Pac-Man collects, the higher the score the player achieves. This gameplay design not only promotes healthy eating habits by encouraging the consumption of nutritious foods but also adds a time-bound challenge, making the game engaging and rewarding for players (see Figure 31).

5.2.1.2 Persuasive Loss game framing (LF):

This approach involves integrating elements of game design and gameplay mechanics while emphasizing the potential losses or negative consequences associated with not engaging in desired behaviours or actions within the game.

In this version of Pac-Man, the game environment is filled with mostly unhealthy food items like candies, chips, and soda cans. These unhealthy foods are constantly moving around the maze, actively chasing after Pac-Man. The player's goal is to evade all these unhealthy foods within a specified time limit. If Pac-Man is caught by an unhealthy food item, the player's health decreases. The challenge for the player lies in manoeuvring Pac-Man skilfully to avoid being caught by the unhealthy foods. As time passes, the unhealthy foods become more aggressive and faster, making it increasingly difficult for Pac-Man to evade them. The player must use strategic movements and quick reflexes to survive and maintain Pac-Man's health throughout the game. This version of Pac-Man emphasizes the negative consequences of being caught by unhealthy foods. Players are motivated to make healthier choices by avoiding these items, showcasing how framing can impact player behaviour in a gaming context (see Figure 32).

5.2.1.3 Persuasive Gain-Loss game framing (GLF):

This approach integrates elements of game design and gameplay mechanics while strategically emphasizing both the potential gains and losses associated with specific behaviours or choices within the game.

In this version of Pac-Man, the maze is populated with both healthy food items like fruits and vegetables and unhealthy food items like candies and junk food. Both types of food items are constantly moving around the maze. The player's objective is twofold: Pac-Man needs to consume all the healthy food items while simultaneously avoiding the unhealthy foods, all within a specified time limit. Players gain points for every healthy food item consumed, reflecting the positive aspect of the gain framing. However, if Pac-Man encounters an unhealthy food item, points are deducted, representing the loss aspect of the framing. The healthier items contribute positively to the player's score, while encounters with unhealthy items result in a penalty, reflecting the dual nature of gain-loss framing. This version of Pac-Man creates a dynamic and challenging gameplay experience where players must make quick decisions to balance collecting points through healthy food consumption and avoiding penalties by steering clear of unhealthy foods. The gain-loss framing encourages players to prioritize healthy choices while penalizing interactions with unhealthy items, promoting a balanced and health-conscious gameplay approach (see Figure 33).

Figure 31 - Screenshot of gameplay for the Pac-Man Gain-Framing version.

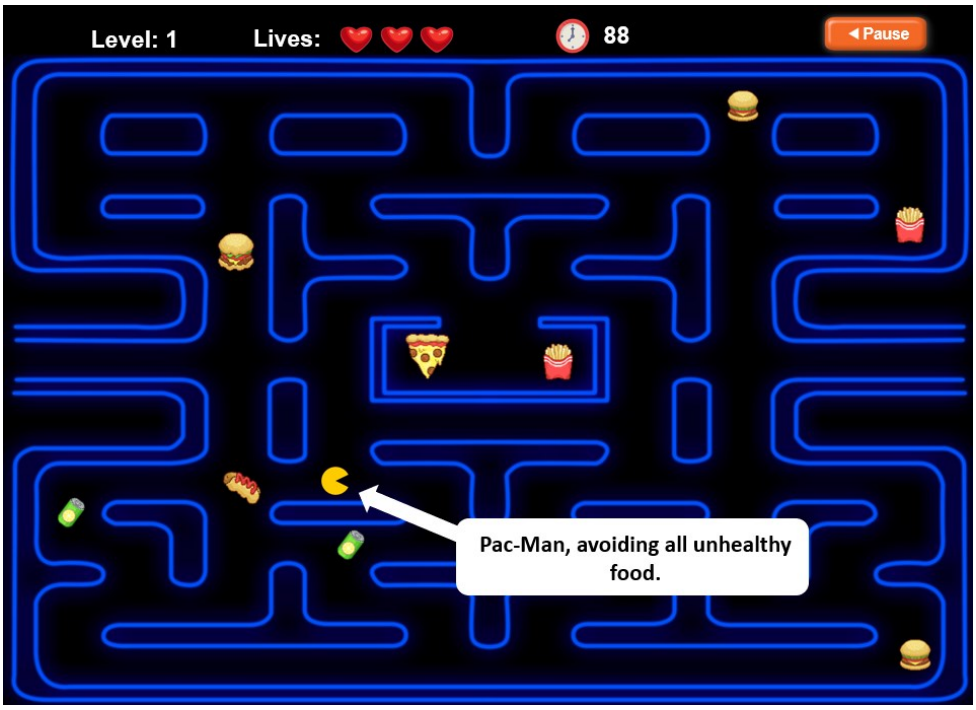

Figure 32 - Screenshot of gameplay for the Pac-Man Loss-Framing version.

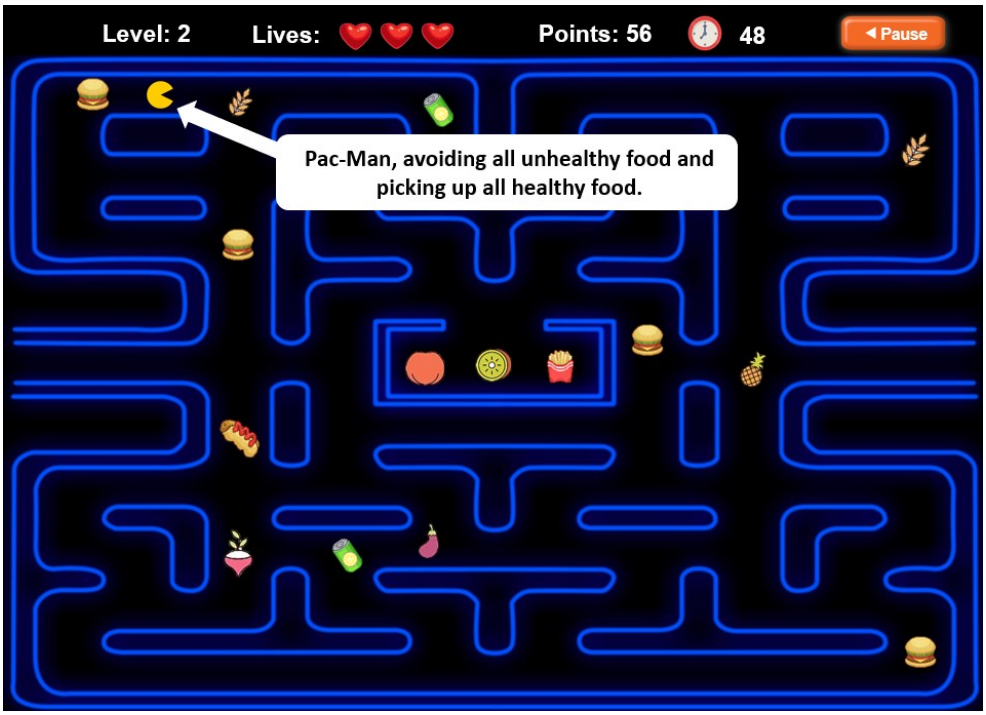

Figure 33 - Screenshot of gameplay for the Pac-Man Gain-Loss-Framing version.

5.2.2 Measurement Instrument

In this study, our main objective was to investigate possible differences in the effectiveness of persuasive games and persuasive strategies across three different game framing types – gain-framing, loss-framing, and gain-loss-framing. To achieve this, we designed three versions of a persuasive game for healthy eating as described in the previous section. Then, we intentionally implemented four persuasive strategies from the PSD model in the same way. They are Reward, Competition, Suggestion, and Praise strategies. Table 18 shows the implementations of these strategies while Figure 34, Figure 35, Figure 36, and Figure 37 are screenshots of some of the strategies.

Table 18 - Persuasive strategies and their implementations

Strategy	**Implementation**
Reward	Badges and points for completing in-game achievements.

	The badges were designed to align with the characteristics of each framing type. In the gain-framed version, players earned the 'selector' badge upon collecting 100 healthy foods. In the loss-framed game, the badge was achieved by avoiding the attack of 100 unhealthy foods while in the gain-loss-framed version, players obtained the selector badge by collecting 50 healthy foods and avoiding 50 unhealthy foods (Figure 34).
Competition	A leaderboard of points earned in-game. Players are ranked according to the points accumulated while playing the game (Figure 35).
Suggestion	Random pop-up tips about healthy eating or unhealthy eating practices. The tips were also strategically tailored to match the characteristics of each framing type. In the gain-framed version, players were motivated to make healthier choices through suggestions of nutritious foods and their nutritional contents. In the loss-framed version, players were dissuaded from consuming unhealthy foods through random tips highlighting the negative aspects of these food items. In the gain-loss version, players received tips that both encouraged healthy eating and discouraged indulging in unhealthy options, striking a balance between positive and negative reinforcement (Figure 36).
Praise	Image and textual positive feedback for completing in-game achievements (Figure 37).

After gameplay, to collect feedback from participants on the effectiveness of these strategies, the participants filled out a survey in the P-Gamer platform that asked users to rate their perceived effectiveness of the strategies. The survey collected the perceived effectiveness of the overall game and the four persuasive strategies implemented in the game. The questionnaire was based on a scale adapted from Thomas et al. [162] and Drodz et al. [44]. The scale is a well-established measure used to evaluate the perceived persuasiveness of system features, and it has been utilized

in various Human-Computer Interaction (HCI) and related research studies [44][29][118][121]. The scale consisted of the following questions:

i. *"This feature/game would influence me to eat healthily."*
ii. *"This feature/game would convince me to eat healthily."*
iii. *"This feature/game would be personally relevant to me."*
iv. *"This feature/game would make me reconsider my eating habits."*
v. *"The feature would make or motivate me to play the game."*

We measured these questions on a 7-point Likert scale ranging from "1 = Strongly disagree" to "7 = Strongly agree" for each strategy and the overall game. Additionally, each item was accompanied by an open-ended question to capture qualitative comments, allowing participants to justify their ratings and express their opinions on the features, including what they liked or disliked about them.

5.2.3 Demographic Information

Initially, we recruited 409 participants, who installed the game on their personal computers. The participants were instructed to engage with the game for a minimum of 15 minutes per day over three consecutive days. At the end of the gameplay duration, they filled out the survey to capture their perceptions regarding the game's effectiveness and the four strategies that had been implemented within the game. However, after excluding participants who did not fill out the survey, a total of 371 participants were included in the analysis. In a between-study design, participants were distributed across the game framings as follows: 125 participants for the gain-framing condition, 122 participants for the loss-framing condition, and 124 participants for the gain-loss-framing condition. Table 19 shows the demographic distribution of participants.

Figure 34 - Reward (Badges) in Gain-Loss Framing version

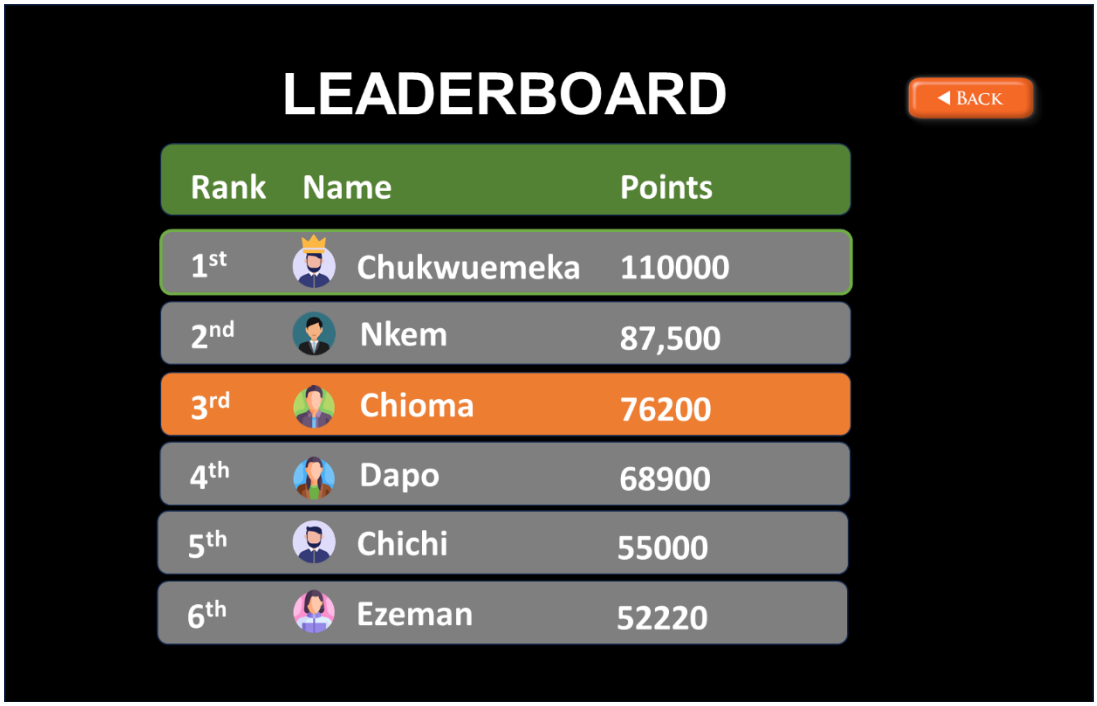

Figure 35 - Competition in the Loss Framing Version

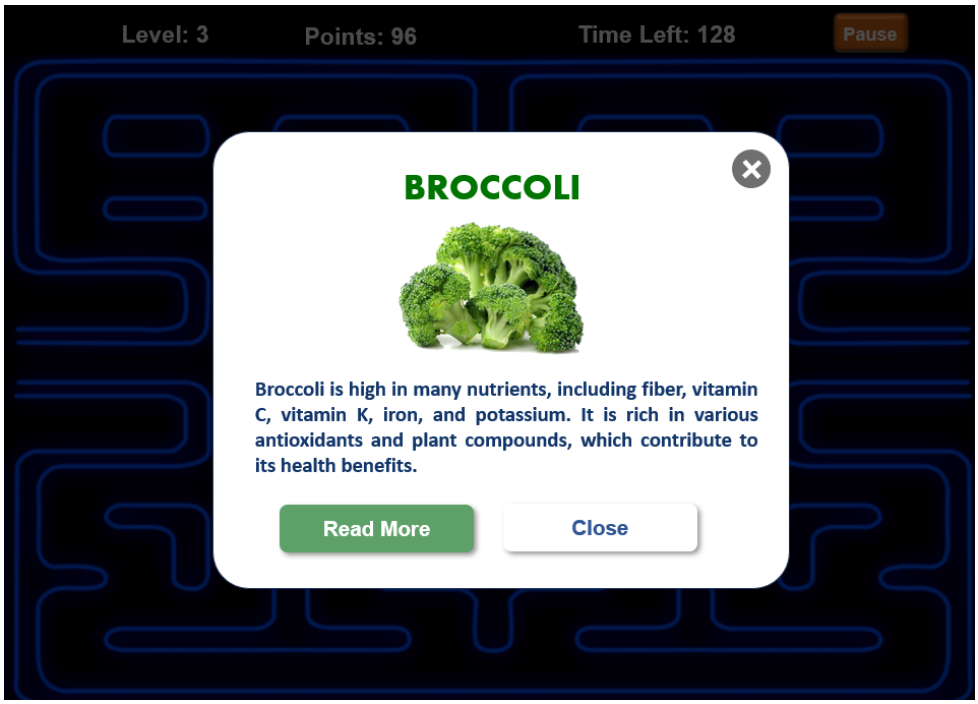

Figure 36 - Suggestion in the Gain Framing Version

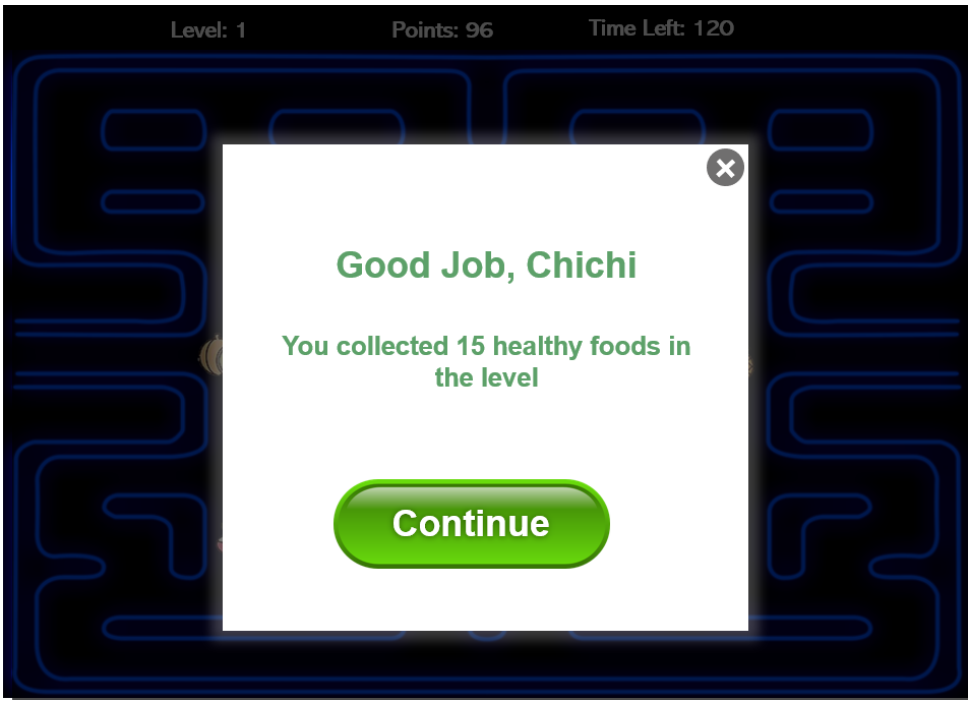

Figure 37 - Praise in the Gain Framing version

Table 19 - Demographic distribution of the study

	Overall	Gain	Loss	Gain-Loss
Total	371	125	122	124
Gender	Female = 30% (112), Male = 70% (259)	Females = 43 females, Males = 82 males	Females = 38, Male = 84.	Females = 31, Males = 93
Age	18-25 = 29% (106), 26-35 = 51% (189), 36-45 = 20% (76).	18-25 = 41, 26-35 = 60, 36-45 = 24.	18-25 = 36, 26-35 = 65, 36-45 = 21.	18-25 = 29, 26-35 = 64, 36-45 = 31.
Education	Bachelors = 69% (255), Masters = 23% (85), High School = 5% (19), Diploma = 3% (12)	Bachelors = 90, Masters = 26, High School = 5, Diploma = 4	Bachelors = 87, Masters = 27, High school = 7, Diploma = 1	Bachelors = 78, Masters = 19, High School = 7, Diploma = 7

5.3 Data analysis

Our main objective in this research was to investigate the effectiveness of the game and the persuasive strategies across three game framing types. To achieve this, we carried out the following analysis:

i. *To determine the suitability of our data for analysis, we carried out a Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and the Bartlett Test of Sphericity* [80]. *Specifically, we measured the sampling adequacy of the variables in our data. Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity essentially check to see if the variables are related and can be summarized with fewer factors. That is if there are redundancies between the variables we can summarize with fewer factors. While the recommended KMO value should not be less than 0.6, for excellent factor data analytic, the KMO value should be at least 0.8* [80].

ii. *We conducted a One-Sample t-test on the overall rating of each version of the game, to verify the perceived effectiveness of each version.*

iii. *We conducted a repeated measure ANOVA on the mean ratings of each game version and each persuasive strategy to identify the significant difference in their effectiveness. The analysis was conducted after validating the ANOVA assumptions.*

iv. *Using SmartPLS 4* [137]*, we applied Partial Least Squares Structural Equation Modeling (PLS-SEM) to develop models illustrating the relationships between the persuasiveness of*

strategies and the four ARCS motivational constructs across the three game framings. PLS-SEM is a widely utilized method for estimating path models that unveil intricate interconnections between observed and latent variables [151]*. The choice of PLS-SEM over other approaches, such as covariant-based methods, stems from its suitability for handling complex predictive models* [88]*, and it has demonstrated success in estimating relationships between variables in the context of Human-Computer Interaction (HCI) research* [12, 103, 130]*. Models were developed for each motivational appeal construct, addressing one strategy at a time.* Figure 38 *illustrates the PLS-SEM structural model, displaying the relationships between the ARCS motivational constructs and each strategy.*

v. *Using SmartPLS 4* [137]*, We conducted a multi-group comparison, followed by Bonferroni adjustment, to examine differences in relationships between the persuasiveness of strategies and the four ARCS motivational constructs across models for the three game framings.*

5.3.1 Structural Model

After determining the suitability of our data, we used PLS-SEM to develop models showing the relationship between the effectiveness of the persuasive strategies and their motivational appeal in each game framing type separately. Figure 38 shows an overview of the general model. PLS-SEM is a recommended technique for modelling relationships between variables [88]. According to Hair et al. [64], the PLS-SEM is preferred "when the structural model is complex and includes many constructs, indicators and/or model relationships". As recommended, we validated the measurement model before estimating the structural paths to test for the relationship between the variables using the criteria suggested for assessing PLS-SEM model validity and reliability [62]. Specifically, we performed PLS-SEM model validity and reliability checks using a set of common criteria as shown below and in Appendix C.

i. **Indicator Reliability**: Internal reliability assesses the consistency of results across items within a test. Our examination of the indicator loadings of the models showed that they were all above the recommended value which is 0.7 [32].

ii. **Internal Consistency**: We assessed the internal consistency and reliability using composite reliability (CR) and Cronbach's alpha and all were higher than their threshold value of 0.7 [32]. The composite reliability and Cronbach's alpha are used to analyze the strength of each indicator's correlation with their variables.

iii. **Convergent Reliability**: Convergent reliability refers to how closely each variable is related to other variables and other measures of the same construct. We also checked the data for convergent reliability by assessing the average variance extracted (AVE) by the variables from its indicator items and all constructs have an AVE above the recommended threshold of 0.5 [32].

iv. **Discriminant Validity**: The Discriminant validity test is used to show that two measures that are not supposed to be related are in fact, unrelated. We assessed discriminant validity using the Heterotrait-Monotrait (HTMT) ratio of correlations and found that HTMT was all below the recommended limit of 0.9 [32].

The measurement models yielded an acceptable value of all indices for PLS model validity and reliability. The tables in the Appendix C show the Cronbach's alpha, Composite Reliability, AVE, and HTMT values of the model for the two domains.

Finally, before we investigate for significant differences in these relationships (path coefficient) between the models for the different game framings, there is a need to establish that we are not comparing dissimilar groups. We established measurement invariance following the three-step procedure established for PLS-SEM [72]. Measurement invariance in the models is a statistical property that indicates that the same underlying construct is being measured across the game framings [3, 25]. We established (1) configural invariance which ensures that the same basic factor structure exists in all the groups, (2) compositional invariance (i.e., equal indicator weights), and (3) the equality of composite mean values and variances across groups.

To examine, for significant differences in path coefficient (Beta) across the framing types, we followed the method in [35, 150], which has been used in other works including [124]. After establishing invariance, we ran the PLS Algorithm and Bootstrap and recorded the Standard Error (SE) and Beta for each construct, which we used to calculate the pairwise t-statistics and

corresponding p-value to test for significant differences in beta [35, 150], using pairwise comparison approach [35, 150]. A significant *p-value* indicates a significant Beta difference across the game framings.

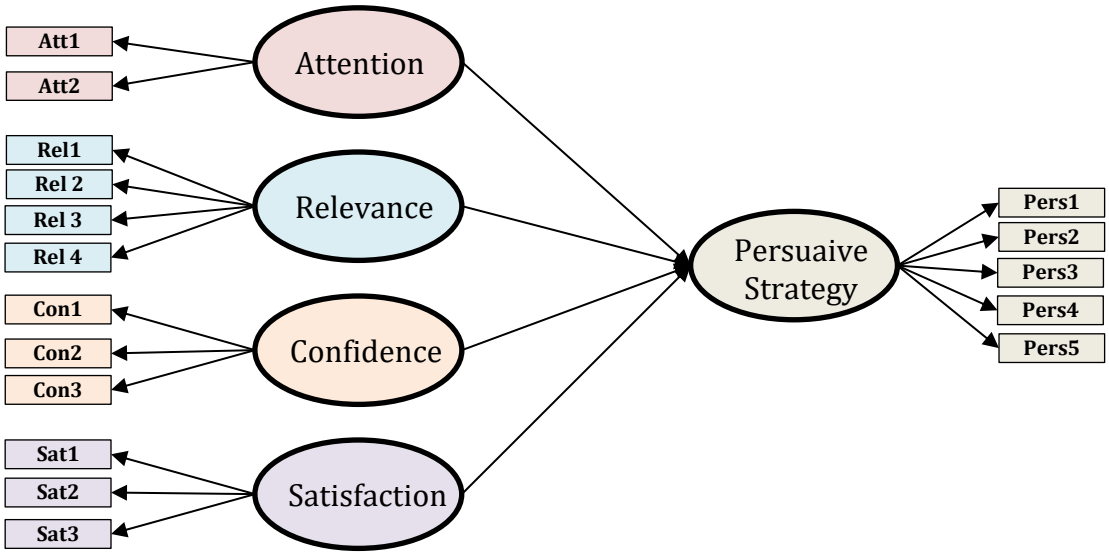

Figure 38 - PLS-SEM structural model showing the relationship between the ARCS motivational constructs and each persuasive strategy in each framing. This model was repeated for each strategy across the three domains.

5.4 Results

Before exploring our specific research questions, it was essential to validate the perceived effectiveness of the game versions and the persuasive strategies implemented, despite the existing body of research indicating the effectiveness of persuasive games. This preliminary step ensures a robust foundation for our study and allows us to contextualize our findings within the framework of existing research. We performed one-sample t-tests on the mean scores of user ratings for both the game versions and the persuasive strategies. The tests were conducted with a reference to the neutral rating of 4 on a 7-point persuasiveness scale.

Our findings indicated that all versions of the game, regardless of the framing, were perceived as significantly effective in their persuasive impact – gain-framing ($t(124)=31.54$, $p<.001$), loss-framing ($t(121)=39.16$, $p<0.001$), and gain-loss-framing ($t(123)=36.88$, $p<.001$). Furthermore, the

persuasive strategies deployed within the game were perceived as significantly effective across all framing types, as illustrated in Table 20 and Figure 39.

Table 20 - T-Test of the mean values of the three-game versions and the persuasive strategies implemented. (All means were significant at p<.0001, test value = 4).

	Gain Framing				**Loss Framing**				**Gain-Loss Framing**			
	df = 124				df = 121				df = 123			
Strategies	M	SD	t	p	M	SD	t	p	M	SD	t	p
Reward	5.63	0.819	22.29	.001	5.98	0.643	33.98	.001	6.04	0.852	26.59	.001
Competition	5.67	0.869	21.46	.001	6.00	0.700	31.55	.001	6.08	0.856	27.04	.001
Praise	5.48	0.962	17.20	.001	5.53	0.895	18.85	.001	5.48	0.915	17.96	.001
Suggestion	5.50	0.967	17.36	.001	5.50	1.120	14.77	.001	5.57	0.841	20.71	.001
Overall	5.57	0.551	31.85	.001	5.75	0.494	39.16	.001	5.79	0.540	36.89	.001

M = mean, df = degree of freedom, SD = Standard Deviation, t = t-value, p = p-value.

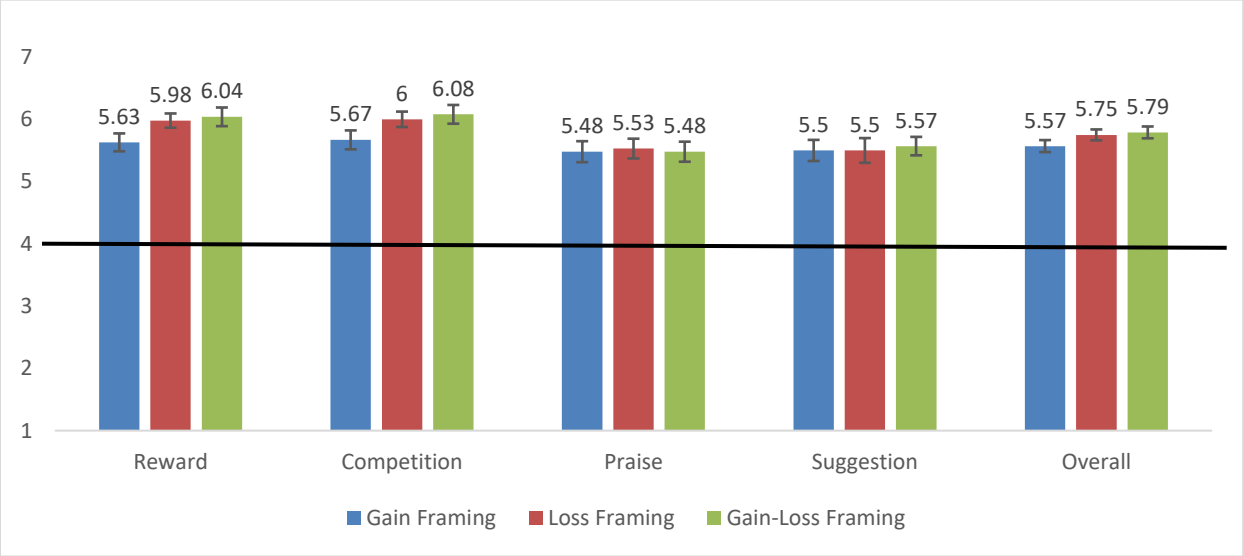

Figure 39 - A bar chart showing the perceived effectiveness of the game overall and its persuasive strategies, across the game framings.

To address our first research question, (RQ3a) – *How does game framing impact the perceived effectiveness of persuasive games?*, we conducted a repeated measure ANOVA on the mean ratings of the game across the three framing types. Our results showed that there was a significant main effect of gain framing across the games overall with a large effect size: $F(2,242) = 6.063$, $p=0.003$, $\eta 2 \geq 0.48$). Furthermore, a post-hoc pairwise comparison revealed that there was a significant difference in perceived effectiveness between the gain-framed version and the loss-

framed version as shown in Table 21. It indicated that the loss-framed version was perceived as significantly more effective than the gain-framed version. Additionally, there was also a significant difference in perceived effectiveness between the gain-framed and gain-loss-framed versions. This also indicated that the gain-loss-framed version was perceived as significantly more effective than the gain-framed version. Interestingly, there was no statistically significant difference between the loss-framed and the gain-loss-framed version.

The results highlight that both the loss-framed and gain-loss-framed versions were generally perceived as more effective than the gain-framed version. However, interestingly, there was no discernible difference in the perceived effectiveness between the gain-loss version and the loss-framed version. This suggests that the gain-loss-framed version, while more effective, did not hold a significant advantage over the loss-framed version in terms of perceived effectiveness at promoting behaviour change.

Table 21 – Pairwise comparisons of the perceived effectiveness of the framing across the three versions and their strategies. (The highlighted cells show significance at $p<0.05$)

	GF vs LF	**LF vs GLF**	**GLF vs GF**
Reward	.001	1.00	.001
Competition	.001	1.00	.001
Praise	1.00	1.00	1.00
Suggestion	1.00	1.00	1.00
Overall	0.017	1.00	0.008
GF= Gain-Framing, LF = Loss-Framing, GLF = Gain-Loss-Framing			

In response to research question, (R3b) – *How does game framing impact the perceived effectiveness of the persuasive strategies embedded in games for behaviour change?*, we also conducted a repeated measure ANOVA on the mean ratings of the four persuasive strategies (Reward, Competition, Praise and Suggestion) across the three framing types.

5.4.1 Game Framing on Reward and Competition

The analysis demonstrated a significant main effect across these the reward and competition strategies employed in the three game framing versions. Specifically, for the reward strategy, the main effect of game framing was significant with a large effect size ($F(2,242) = 9.940$, $p < 0.001$,

$\eta 2 \geq 0.76$). Similarly, for the competition strategy, after applying the Greenhouse-Geisser correction, the main effect of game framing remained significant with a large effect size ($F(1.882,232.9) = 10.14$, $p < 0.001$, $\eta 2 \geq 0.77$). The Greenhouse-Geisser correction is a statistical adjustment applied in repeated measures ANOVA to mitigate violations of the sphericity assumption, which assumes that the variances of differences between all possible pairs of within-subject conditions are equal [22].

Furthermore, a post-hoc pairwise comparison also revealed that there was a significant difference in the perceived effectiveness of these two strategies between the gain-framed version and the loss-framed version as shown in Table 21. It results indicate that the loss-framed version was perceived as significantly more effective than the gain-framed version. Additionally, there was also a significant difference in perceived effectiveness between the gain-framed and gain-loss-framed, with the gain-loss-framed version perceived as significantly more effective than the gain-framed version. Surprisingly, no significant difference emerged between the loss-framed and gain-loss-framed versions.

These findings indicate that both the reward and competition persuasive strategies exhibit significantly higher perceived effectiveness when implemented in the loss-framed version compared to the gain-framed game. Moreover, the results show a significant increase in perceived effectiveness when these strategies are implemented in the gain-loss-framed version compared to the gain-framed version. Interestingly, our observations reveal that while these two strategies implemented in the gain-loss-framed version proved to be more effective, they did not demonstrate a significant advantage when compared to the loss-framed version.

5.4.2 Game Framing on Praise and Suggestion

However, for the praise and suggestion strategies, the analysis revealed a non-significant main effect of game framing in the three versions. For the Praise strategy, the results indicated no significant differences ($F(2,242) = 0.106$, $p = 0.90$, $\eta 2 \geq 0.001$), while for the Suggestion strategy, the analysis similarly showed no significant variances ($F(2,242) = 0.154$, $p = 0.86$, $\eta 2 \geq 0.001$).

The non-significant outcomes from our analysis indicate that there were no statistically significant differences in the perceived effectiveness of the praise and suggestion persuasive strategies across all game framings. This implies that irrespective of the framing type, the praise and suggestion persuasive strategies are similarly effective. In other words, the impact of these strategies remained consistent and unaffected by the specific framing employed in the game design.

5.4.3 The relationship between the effectiveness of persuasive strategies and their motivational appeal in each game framing

To address Research Question (R3a) regarding the relationship between the effectiveness of persuasive strategies and their motivational appeal within each game framing, we developed a structural model showing the relationship between the persuasiveness of the strategies and their motivational appeal for each game framing. Our goal was to understand the relationships between the effectiveness of these persuasive strategies and the four dimensions of motivational appeal: attention, relevance, confidence, and satisfaction. The subsequent sections present the outcomes specific to each game framing version. Table 22, Table 23 and Table 24 show the path coefficients of these relationships (beta), with the bolded values indicating stronger relationships and the '-' denoting no significant relationship.

5.4.3.1 Gain Framing

In the gain-framed version, we observed that all persuasive strategies showed significant relationships with three of the four dimensions of motivation – attention, confidence, and satisfaction as shown in Table 22. Additionally, reward, competition, praise, and suggestion exhibited significant relationships with the relevance dimension, but competition did not.

In terms of the overall strength of relationships across motivational dimensions, our analysis indicated that all four strategies collectively demonstrated stronger relationships with attention. The respective path coefficients for attention were as follows: reward ($\beta = 0.275$, $p < 0.001$), competition ($\beta = 0.326$, $p < 0.001$), praise ($\beta = 0.289$, $p < 0.001$), and suggestion ($\beta = 0.266$, $p < 0.001$). Notably, relevance showed a stronger relationship with suggestion ($\beta = 0.342$, $p < 0.001$),

suggesting that, within the gain-framed version, the suggestion strategy particularly stood out in terms of its impact on perceived relevance.

Regarding confidence, no distinct patterns of stronger relationships were identified across the four strategies. However, in the case of satisfaction, our findings revealed stronger relationships with reward ($\beta = 0.268$, $p < 0.001$) and competition ($\beta = 0.335$, $p < 0.001$). This indicates that, within the gain-framed context, individuals feel a great sense of satisfaction with the reward and competition persuasive strategies.

Table 22 – Standard path coefficients and significance of relationships in the gain-framed version. Bolded coefficients have significance levels of p<.001, while unbolded coefficients have significance levels of p<.05. "–" represents non-significant coefficients

Gain Framing				
Strategy	**ATT**	**REL**	**CON**	**SAT**
Reward	0.275	0.244	0.243	0.268
Competition	0.326	-	0.202	0.335
Praise	0.289	0.304	0.238	0.187
Suggestion	0.266	0.342	0.196	0.202
ATT = Attention, REL = Relevance, CON = Confidence, SAT = Satisfaction				

5.4.3.2 Loss Framing

In the loss-framed version, all the persuasive strategies showed significant relationships with attention and confidence as shown in Table 23. However, although reward, competition, and suggestion showed significant relationships with relevance, praise did not.

Analyzing the overall strength of the relationships across motivational dimensions, we found that attention demonstrated a stronger relationship with only the suggestion strategy ($\beta = 0.327$, $p < 0.001$). This suggests that, within the loss-framed version, the suggestion strategy particularly stood out in terms of its ability to capture individuals' attention. Contrastingly, for relevance, we did not identify stronger relationships with any specific strategy.

Examining the confidence dimension, our findings indicated a stronger relationship with only the competition strategy ($\beta = 0.417$, $p < 0.001$). This suggests that, within the loss-framed context, individuals perceived a greater boost in confidence in response to the competition persuasive strategies.

Furthermore, satisfaction exhibited stronger relationships with only the suggestion strategy ($\beta = 0.320$, $p < 0.001$). This implies that, within the loss-framed version, individuals experienced higher levels of satisfaction in response to the suggestion strategy compared to other persuasive approaches.

Table 23 – Standard path coefficients and significance of relationships in the loss-framed version. Bolded coefficients have significance levels of p<.001, while unbolded coefficients have significance levels of p<.05. "–" represents non-significant coefficients

Loss Framing				
Strategy	**ATT**	**REL**	**CON**	**SAT**
Reward	0.200	0.273	0.273	0.189
Competition	0.265	0.182	0.417	-
Praise	0.233	-	0.246	0.300
Suggestion	0.327	0.189	0.162	0.320
ATT = Attention, REL = Relevance, CON = Confidence, SAT = Satisfaction				

5.4.3.3 Gain-Loss Framing

In the gain-loss-framed version, we observed that all the persuasive strategies exhibited significant relationships with relevance, confidence, and satisfaction as shown in Table 24. However, although reward, competition, and suggestion showed significant relationships with relevance, praise did not.

Analyzing the overall strength of relationships across motivational dimensions shows that attention displayed a stronger relationship with only the reward strategy ($\beta = 0.345$, $p < 0.001$). This implies that, within the gain-loss-framed version, the reward strategy particularly stood out in terms of its impact on capturing individuals' attention.

Concerning confidence, no distinct patterns of stronger relationships were identified across the four strategies. However, relevance exhibited stronger relationships with both the praise ($\beta = 0.275$, $p < 0.001$) and suggestion ($\beta = 0.321$, $p < 0.001$) strategies. This suggests that, within the gain-loss-framed context, the use of praise and suggestion strategies increases the perceived relevance of the application for the users.

Satisfaction, on the other hand, demonstrated the highest amount of stronger relationships with competition ($\beta = 0.291$, $p < 0.001$), praise ($\beta = 0.451$, $p < 0.001$), and suggestion ($\beta = 0.261$, $p < 0.001$). This indicates that, within the gain-loss-framed version, these three strategies were particularly effective in increasing the level of satisfaction individuals drive from using the applications..

Table 24 – Standard path coefficients and significance of relationships in the gain-loss-framed version. Bolded coefficients have significance levels of p<.001, while unbolded coefficients have significance levels of p<.05. "–" represents non-significant coefficients

Gain-Loss Framing				
Strategy	ATT	REL	CON	**SAT**
Reward	0.35	0.29	0.24	0.16
Competition	0.27	0.23	0.18	**0.29**
Praise	-	0.28	0.13	**0.45**
Suggestion	0.193	0.32	0.20	**0.26**
ATT = Attention, REL = Relevance, CON = Confidence, SAT = Satisfaction				

5.4.4 The relationship between Motivational Dimensions and Persuasive Strategies across game framings

To answer Research Question 3 (R3b) regarding the differences in the relationship between the effectiveness of persuasive strategies and their motivational appeal in behaviour change games across the three game framing versions, the results of our multi-group comparison revealed that individual persuasive strategies showed a significant impact on motivation, albeit at varying degrees, for participants across different game framings, as illustrated in Table 25. The subsequent sections present the detailed results of the multi-group analysis for each strategy.

Table 25 – Standard path coefficients and significance of the multigroup comparison across game framings. Bolded coefficients have significance levels of p<.001, while unbolded coefficients have significance levels of p<.05. "–" represents non-significant coefficients

Strategy	**Game Framing**	**ATT**	**REL**	**CON**	**SAT**
Reward	Gain-Framing	0.275	0.244	0.243	0.268
	Loss-Framing	0.200	0.273	0.273	0.189
	Gain-Loss Framing	0.345	0.287	0.239	0.163
Competition	Gain-Framing	0.326	-	0.202	0.335
	Loss-Framing	0.265	0.182	0.417	-
	Gain-Loss Framing	0.272	0.233	0.179	0.291
Praise	Gain-Framing	0.289	0.304	0.238	0.187
	Loss-Framing	0.233	-	0.246	0.300
	Gain-Loss Framing	-	0.275	0.130	0.451
Suggestion	Gain-Framing	0.266	0.342	0.196	0.202
	Loss-Framing	0.327	0.189	0.162	0.320
	Gain-Loss Framing	0.193	0.321	0.200	0.261
	ATT = Attention, REL = Relevance, CON = Confidence, SAT = Satisfaction				

5.4.4.1 Reward:

The reward strategy involves offering incentives to players to motivate and encourage desired behaviours or actions. This strategy was implemented as badges for accomplishing in-game goals related to healthy eating. Our multi-group analysis results demonstrated that the reward strategy exhibited a significant relationship with Attention, Relevance, Confidence, and Satisfaction in participants across all game framing types, as shown in Table 25. This implies that irrespective of the framing employed, badges effectively contributed to enhancing players' attention, confidence, relevance, and satisfaction in the context of the healthy eating persuasive game.

Remarkably, our findings indicated a significantly stronger relationship between reward and attention in both the gain-framed version ($\beta = 0.275$, $p < 0.001$) and the gain-loss-framed version ($\beta = 0.268$, $p < 0.001$). This suggests that the reward strategy had a particularly pronounced impact on capturing players' attention when presented within these specific framing contexts.

Additionally, the reward strategy demonstrated a more substantial relationship with satisfaction in the gain-framed version ($\beta = 0.345$, $p < 0.001$). This implies that, within the gain-framed version, the use of badges for achieving healthy eating goals elicited a heightened sense of satisfaction among players compared to other framing scenarios.

5.4.4.2 Competition:

The competition strategy involves encouraging players to compete with others, thereby motivating them to achieve desired goals or outcomes. In our study, this strategy was implemented through global leaderboards that ranked players based on their in-game points. The results of our multi-group analysis revealed that the competition strategy exhibited a significant relationship with Attention and Confidence across all game framing types, as outlined in Table 25. This indicates that irrespective of the framing employed, the presence of leaderboards effectively fostered attention and confidence among players in the context of healthy eating.

Notably, the analysis revealed that the competition strategy had a significant relationship with Relevance only in the loss-framed and gain-loss-framed versions. This suggests that the competitive element associated with leaderboards played a more pronounced role in influencing the perceived relevance of healthy eating goals in these specific framing contexts.

Additionally, our findings indicated that Satisfaction showed a significant relationship with the competition strategy only in the gain-framed and gain-loss-framed versions. This implies that, within these framing scenarios, the competitive aspect introduced through leaderboards contributed significantly to players' satisfaction with the healthy eating persuasive game.

Furthermore, we observed a stronger relationship between Attention and the competition strategy in the gain-framed version ($\beta = 0.326$, $p < 0.001$), Confidence and competition in the loss-framed version ($\beta = 0.417$, $p < 0.001$), and Satisfaction and competition in the gain-loss-framed version ($\beta = 0.291$, $p < 0.001$). These findings suggest that the impact of the competition strategy on attention, confidence, and satisfaction varied in strength across different framing versions.

5.4.4.3 Praise:

The praise strategy involves leveraging positive feedback or compliments to reinforce desired behaviours or achievements. In our study, this strategy was implemented through the provision of images and textual positive feedback for completing in-game achievements. The results of our multi-group analysis demonstrated that praise exhibited a significant relationship with Confidence and Satisfaction across all game framing types, as detailed in Table 25. This implies that, regardless of the framing employed, the incorporation of praise effectively bolstered participants' confidence and satisfaction with respect to healthy eating.

However, the analysis revealed that Attention only showed a significant relationship to praise in the gain-framing and loss-framing versions. This suggests that, in these specific framing contexts, positive feedback played a more pronounced role in capturing players' attention. Similarly, Relevance only exhibited a significant relationship to praise in the gain-framed and gain-loss-framed versions. This implies that the relevance of healthy eating goals was particularly influenced by the incorporation of positive feedback within these framing scenarios.

Furthermore, our findings indicated a more robust relationship between Attention and praise in the gain-framed version ($\beta = 0.289$, $p < 0.001$), Relevance and praise in the loss-framed version ($\beta = 0.275$, $p < 0.001$), and Satisfaction and praise in the gain-loss-framed version ($\beta = 0.451$, $p < 0.001$). These observations suggest that the impact of the praise strategy on attention, relevance, and satisfaction varied in strength across different framing versions.

5.4.4.4 Suggestion:

The suggestion strategy involves providing recommendations to players and suggesting specific actions or behaviours to motivate them to adopt desired habits or decisions. In our study, this strategy was implemented through the presentation of random pop-up tips about healthy eating or unhealthy eating practices. Our multi-group analysis results demonstrated that the suggestion strategy exhibited a significant relationship with Attention and Confidence across all game framing types, as depicted in Table 25. This indicates that irrespective of the framing employed, the

inclusion of suggestions effectively captured players' attention and enhanced their confidence with respect to their ability to adopt healthy eating behaviour.

Notably, the analysis revealed a stronger relationship between Attention and the suggestion strategy in both the gain-framed version ($\beta = 0.266$, $p < 0.001$) and the loss-framed version ($\beta = 0.327$, $p < 0.001$). This suggests that the suggestion strategy had a particularly pronounced impact on directing players' attention when presented within these specific framing contexts. Similarly, Relevance displayed a stronger relationship with the suggestion strategy in both the gain-framed version ($\beta = 0.342$, $p < 0.001$) and the gain-loss-framed version ($\beta = 0.321$, $p < 0.001$). This implies that, within these framing scenarios, the inclusion of suggestions played a more substantial role in influencing the perceived relevance of healthy eating goals. Furthermore, Satisfaction exhibited a more robust relationship with the suggestion strategy in both the loss-framed version ($\beta = 0.320$, $p < 0.001$) and the gain-loss-framed version ($\beta = 0.261$, $p < 0.001$). This indicates that, within these framing contexts, the suggestion strategy significantly contributed to participants' satisfaction with the healthy eating persuasive game.

5.4.5 Some General Observations from the Results

Confidence emerged as a significant factor for all persuasive strategies across all game framing types, underscoring its consistent importance in influencing participants' responses. Notably, attention displayed the highest number of stronger significances across all the game framing types, as indicated by the bolded values in Table 25.

Among the identified relationships, two stood out as the most significant. Firstly, participants' satisfaction with praise in the gain-framed version exhibited a notably strong association ($\beta = 0.451$, $p < 0.001$), emphasizing the substantial impact of positive feedback on enhancing participants' satisfaction within this framing context. Secondly, confidence demonstrated a robust relationship with competition in the loss-framed version ($\beta = 0.417$, $p < 0.001$), highlighting the influential role of competitive elements in bolstering participants' confidence specifically within the loss-framed environment.

Conversely, two relationships were identified as the least significant among the examined factors. Participants praise showed lower significance relationship with confidence in the gain-loss-framed version ($\beta = 0.130$, $p < 0.001$), suggesting that the impact of positive feedback on participants' confidence was comparatively weaker in the gain-loss-framed context. Similarly, the impact of suggestions on participants' confidence in the loss-framed version displayed lower significance ($\beta = 0.162$, $p < 0.001$), indicating a relatively weaker influence of suggestion-related cues on participants' confidence within the loss-framed environment.

Furthermore, it is noteworthy that both the reward and suggestion strategies demonstrated significance relationships across all motivational appeal dimensions in each of the three game framing versions. This consistent significance emphasizes the broad impact of these strategies on attention, relevance, confidence, and satisfaction, irrespective of the framing employed.

We discuss these results in more detail in Sections 7.2 and 7.3 of this thesis.

CHAPTER 6 The Impact of Game Framing on the Effectiveness of Persuasive Strategies for Gamer Types.

In the previous chapter, we explored the impact of game framing on persuasive strategies and their motivation appeal. In this chapter, we expand on that by investigating the impact of game framing on the effectiveness of persuasive strategies for gamer types. This would answer RQ5 – *What are the relationships between gamer types and the effectiveness of persuasive strategies across game framings*?[6] Specifically, we present the results of a between-study that explores the perceived effectiveness of persuasive strategies across various gamer types within each game framing version of a healthy eating game.

6.1 Motivation of this Chapter

Persuasive games are interactive systems strategically designed to promote behaviour and attitude changes through the implementation of various persuasive strategies [112] [121]. Research has shown that persuasive games are effective at promoting behaviour change across many domains [126][104]. Consequently, there has been a growing investment in designing and developing persuasive gamified systems to address challenges in domains including environmental sustainability [55], promoting personal wellness, managing diseases [107], engaging in preventive behaviours, physical activity [105], healthy eating [119], avoiding risky behaviours, and substance abuse [56].

Previous research has highlighted the inadequacy of a one-size-fits-all approach in designing persuasive games for behaviour change [123]. Therefore, there is a growing focus on exploring how to tailor persuasive games based on user characteristics age groups, gender groups [132], gamer types [123], gamification user type [122], and personality types [11][103]. However, in the

[6] Originally published at **Ndulue, C.**, Orji, R. (2024). Exploring the Influence of Game Framing and Gamer Types on the Effectiveness of Persuasive Games. In: Baghaei, N., Ali, R., Win, K., Oyibo, K. (eds) Persuasive Technology. PERSUASIVE 2024. Lecture Notes in Computer Science, vol 14636. Springer, Cham. https://doi.org/10.1007/978-3-031-58226-4_16

realm of game design, two pivotal factors significantly influencing the effectiveness of persuasive games are game framing and gamer type.

Game framing involves the intentional and strategic design of a game's context, mechanics, and objectives [156]. This concept encompasses three primary types of framing: gain-framing [92], loss-framing [171] and gain-loss-framing [94]. In the field of persuasive games, understanding the relationship between game framing and persuasive strategies is of paramount importance. Game framing not only lays the groundwork for the integration of persuasive game elements but also moulds players' perceptions of the game's purpose, context, and challenges. As a result, it can significantly impact the effectiveness of the embedded persuasive strategies aimed at motivating players toward specific behaviours or attitudes.

On the other hand, gamer type refers to the characteristics and preferences of game players[163]. Understanding different gamer types is essential for tailoring persuasive games to the diverse needs and motivations of the player base [123]. By recognizing the various player profiles and individual differences, game designers can strategies, and implement features and mechanics that resonate with specific gamer types, thereby enhancing the overall engagement and effectiveness of persuasive elements within the game [121]. In essence, the interplay between game framing and gamer type is a key consideration in the design and success of persuasive games. It is therefore important to explore the impact of game framing and gamer type together on the effectiveness of persuasive games and persuasive strategies.

To advance research in this area, firstly, we developed three versions of persuasive games for promoting healthy eating: gain-framing, loss-framing, and gain-loss framing. Secondly, we conducted a large-scale study with 371 participants, exploring how various gamer types, based on the HEXAD Model [163], responded to four persuasive strategies (reward, competition, praise, and suggestion [112]). These strategies were implemented in three different game-framing versions of a Space-Invader-styled persuasive game focused on healthy eating – gain-framing, loss-framing, and gain-loss framing. Next, we developed models showing how these gamer types respond to the individual strategies in each game framing type using the Partial Least Square Structural Equation Modeling (PLS-SEM) [141]. Our result revealed that, despite the overall

perceived effectiveness of all game versions and persuasive strategies, the reward strategy exhibited a significant overall difference across the three game-framing types. Specifically, it was more effective in the gain-loss framed version when compared to the other two versions We also found that the reward strategy had the highest number of significant relationships with the gamer types across all the game framings, while the suggestion strategy showed no significant relationships with the gamer types across all framings. Our research addresses the following specific research questions:

RQ5a: What is the perceived effectiveness of the persuasive game overall and the individual persuasive strategies implemented in the game across the three game framings?

RQ5b: Are there any differences in the effectiveness of the persuasive game versions and the persuasive strategies across the three game framings?

RQ5c: What are the relationships between gamer types and the effectiveness of persuasive strategies across the three game framing versions?

6.2 Method

In this section, we describe the game design, study design, measurement instrument, participant demography, and the data analysis methods employed in our study.

6.2.1 Game Design

To investigate the impact of game framing on the effectiveness of persuasive games, using the P-Gamer platform, we designed three versions of a space-invader-style game for healthy eating. Each version corresponds to the three different persuasive game framing types. We present each of these framings and their implementation in detail in the following sections.

6.2.1.1 Persuasive Gain game framing (GF).

This game version emphasizes the positive effects (benefits) of healthy eating. Specifically, it integrates elements of game design and gameplay mechanics, emphasizing potential benefits or gains associated with taking specific actions within the game.

In this version, players are incentivized to consume healthy food items. Specifically, they gain points and enhance their in-game performance. The primary objective is to actively engage with and target the nutritious food items within the game environment. Additionally, players must also efficiently gather these healthy food items as they drop down from the top of the screen within a time limit, adding a layer of challenge, skill and timing to the gameplay. The more successfully the player collects and consumes healthy foods, the higher their score, contributing to a positive and rewarding gaming experience with a focus on gaining points and emphasizing the benefits of healthy eating in the game. (see Figure 41).

6.2.1.2 Persuasive Loss game framing (LF).

This game version emphasizes the consequences of unhealthy eating. Specifically, it integrates elements of game design and gameplay mechanics, emphasizing potential losses or negative consequences associated with not engaging in desired behaviours or actions within the game.

In this version, the objective is to eliminate unhealthy food items positioned at the top of the screen. They also must avoid these unhealthy foods as they drop from the top of the same screen. When an unhealthy food item hits the player the player loses some in-game life. This version introduces a risk-reward dynamic, where players must strategically eliminate threats (unhealthy foods) to maintain their in-game vitality, creating a sense of urgency and potential consequences for failing to address the looming "loss" condition (see Figure 40).

6.2.1.3 Persuasive Gain-Loss game framing (GLF).

This game version emphasizes both the benefits and consequences of healthy and unhealthy eating. Specifically, it integrates elements of game design and gameplay mechanics that strategically highlight both the potential gains and losses associated with specific behaviours or choices within the game.

In this version, players encounter a dynamic mix of challenges as both healthy and unhealthy food items populate the game environment. The primary objective is to collect all healthy food items while eliminating and avoiding all unhealthy food items at the top of the screen. Simultaneously,

players must navigate their spaceship to avoid unhealthy foods as they drop from the top while actively collecting healthy ones for points. This version introduces a strategic balance between offensive actions, where players seek to gain points by shooting all food items, and defensive manoeuvres, as they strive to avoid the negative consequences associated with unhealthy foods. The complexity arises from the need to make quick decisions, weighing the potential gains against the risks and consequences of encountering detrimental elements. The gain-loss framing creates a compelling gameplay experience that challenges players to effectively manage both offensive and defensive aspects to succeed in the game, allowing the players to weigh both the benefits of healthy eating and the consequences of unhealthy eating (see Figure 42).

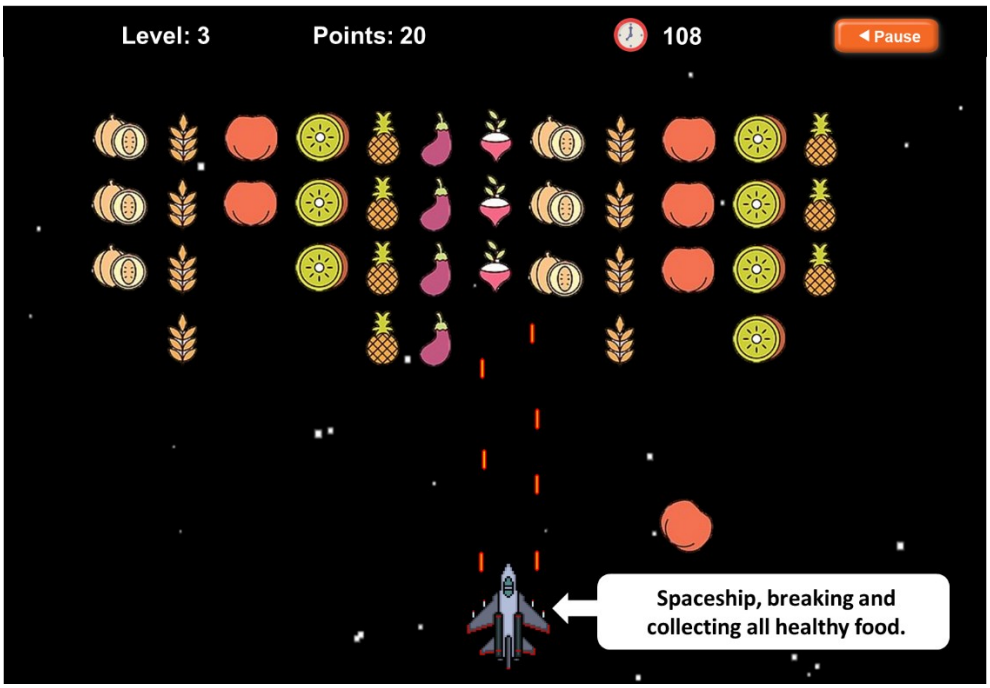

Figure 40 - Screenshot of Space Invader Gain Framing version

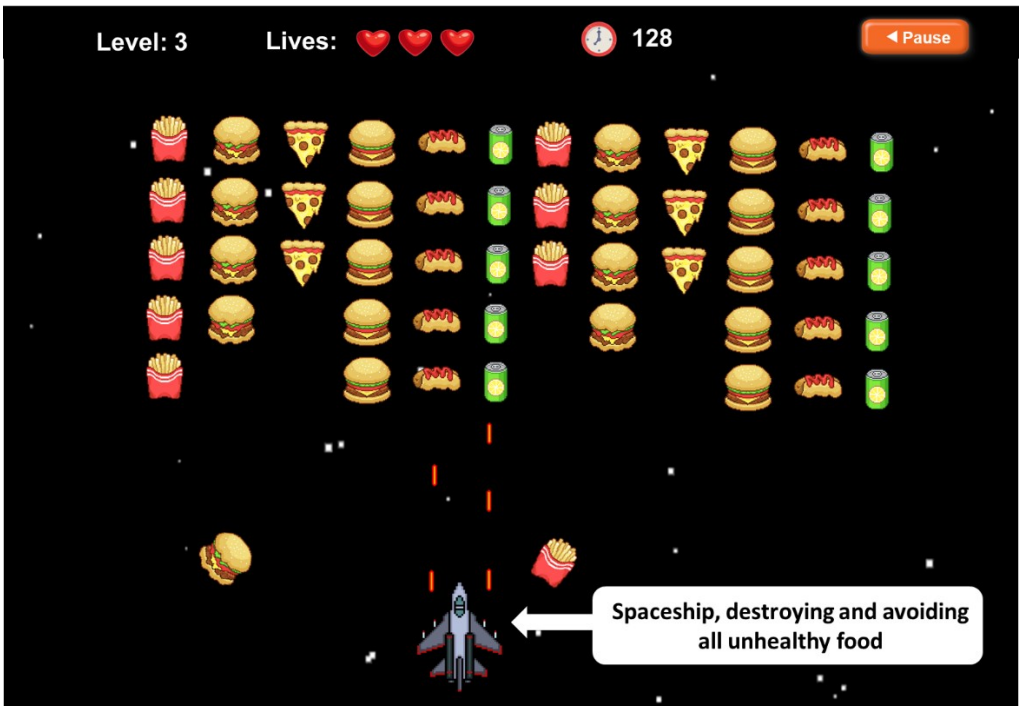

Figure 41 - Screenshot of Space Invader Loss Framing version

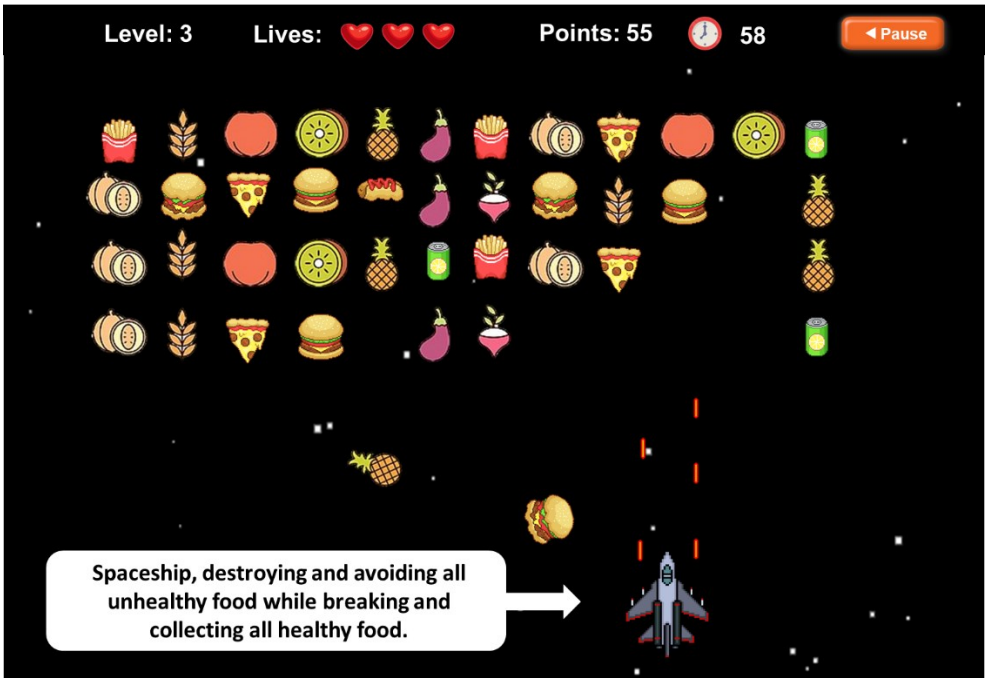

Figure 42 - Screenshot of Space Invader Gain-Loss Framing version

6.2.2 Measurement Instrument and Demographics

As indicated in the previous section, using the P-Gamer platform, we created three versions of a persuasive game for promoting healthy eating, implementing four persuasive system design (PSD) model strategies: Reward, Competition, Suggestion, and Praise [112]. Table 26 shows a description of all the persuasive strategies and their implementations.

To evaluate the effectiveness of game versions and the implemented strategies, we recruited 409 participants, who installed the game and played it game daily for at least 15 minutes over three days. Using a between-study design, participants were allocated to framings: 136 gain-framing, 136 loss-framing, and 137 gain-loss-framing. Table 27 shows the demographic distribution of the participants. After gameplay, to collect feedback from participants on the effectiveness of these strategies, the participants filled out a survey in the P-Gamer platform that asked users to rate their perceived effectiveness of the strategies. The survey collected the perceived effectiveness of the overall game and the four persuasive strategies implemented in the game. The questionnaire was based on a scale adapted from Thomas et al. [162] and Drodz et al. [44]. The scale is a well-established measure used to evaluate the perceived persuasiveness of system features, and it has been utilized in various Human-Computer Interaction (HCI) and related research studies [29][107]. We also collected the participants' gamer type, using the HEXAD scale[163]. We measured these questions on a 7-point Likert scale ranging from "1 = Strongly disagree" to "7 = Strongly agree" for each strategy and the overall game. After excluding incomplete responses, our analysis included 371 responses – 125 gain-framing, 122 loss-framing, and 124 gain-loss-framing.

Table 26. Persuasive strategies and their implementations

Strategy	**Implementation**
Reward	Badges and points for completing in-game achievements. Badges aligned with framing types: Gain-framed achieved by shooting and collecting 100 healthy foods; loss-framed achieved by avoiding 100 unhealthy foods, and gain-loss-framed obtained by collecting 50 healthy foods and avoiding 50 unhealthy foods (See Figure 34).
Competition	In-game leaderboard, tailored to the game framings, ranks players based on accumulated points. (See Figure 35).
Suggestion	Random pop-up tips on healthy and unhealthy eating, tailored to framing types. Gain-framed encourages nutritious choices, loss-framed dissuades unhealthy foods with negative aspects, and gain-loss combines positive and negative reinforcement (See Figure 36).

Praise	Image and textual positive feedback for completing in-game achievements (See Figure 37).

Table 27 - Demographic distribution of the participants

Demographics	**Participants**
Gender	Female = 112 (30%), Male = 259 (70%)
Age Distribution	18-25 = 106 (29%), 26-35 = 189 (51%), 36-45 = 76 (20%)
Educational Background	Bachelor's = 255 (69%), Master's = 85 (23%), High school = 19 (5%), College diploma = 12 (3%).
Framing Type	Gain-framing = 125, Loss-framing = 122, and Gain-loss-framing = 124.

6.3 Data analysis

Our primary research objective was to examine the game's effectiveness across three framing types and understand the relationships between gamer types and implemented persuasive strategies. To achieve this, we conducted the following analysis:

i. *To determine the suitability of our data for analysis, we carried out a Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and the Bartlett Test of Sphericity* [80]. *Specifically, we measured the sampling adequacy of the variables in our data. Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity essentially check to see if the variables are related and can be summarized with fewer factors. That is if there are redundancies between the variables that we can summarize with fewer factors. While the recommended KMO value should not be less than 0.6, for excellent factor data analytic, the KMO value should be at least 0.8 .*

ii. *We conducted a one-sample t-test on the overall rating of each version of the game, to verify the perceived effectiveness of each version.*

iii. *We conducted a repeated measure ANOVA on the mean ratings of each game version and each persuasive strategy to identify the significant difference in their effectiveness. The analysis was conducted after validating the ANOVA assumptions, followed by pairwise comparison (using the Bonferroni method for adjusting degrees of freedom for multiple comparisons)*

iv. *Furthermore, we investigated gamer type relationships with persuasive strategies. We developed structural models depicting relationships between gamer type and strategies persuasiveness (*Figure 43*), with gamer type as exogenous constructs, using Partial Least Square Structural Equation Modeling (PLS-SEM)* [63]. *PLS-SEM is a popular method for estimating complex relationships between observed and latent variables* [152]. *We used SmartPLS 4* [138] *to design the model.*

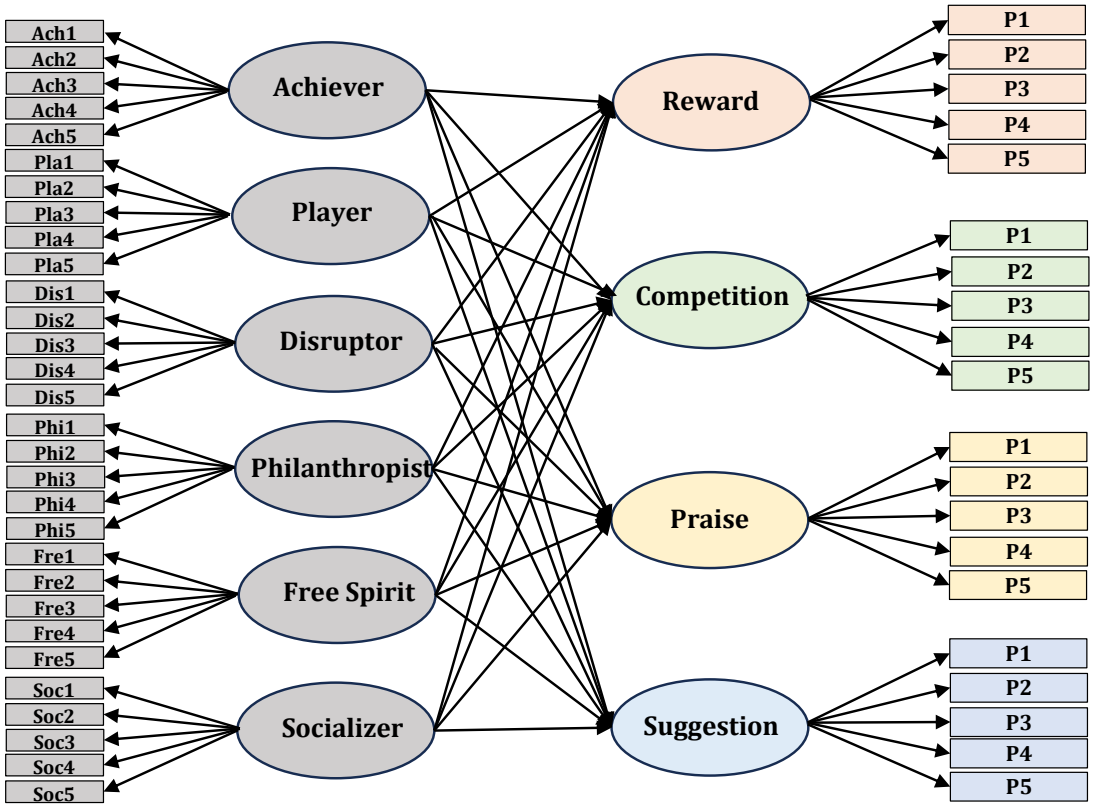

Figure 43 - PLS-SEM model structure for each game framing version. (P1-P5 = Rating responses of the five persuasiveness scale questions; Ach1, Achi2 … Soc1, Soc2 = Rating responses to the HEXAD scale questions for each gamer type).

6.3.1 Structural Model

After determining the suitability of our data, we used PLS-SEM to develop models showing the relationship between the gamer types and the persuasiveness of the strategies in each game framing separately. Figure 43 shows an overview of the general model. PLS-SEM is a recommended technique for modelling relationships between variables [88]. According to Hair et al. [64], the

PLS-SEM is preferred "when the structural model is complex and includes many constructs, indicators and/or model relationships". As recommended, we validated the measurement model before estimating the structural paths to test for the relationship between the variables using the criteria suggested for assessing PLS-SEM model validity and reliability [62]. Specifically, we performed PLS-SEM model validity and reliability checks using a set of common criteria as shown below and in Appendix D.

i. **Indicator Reliability**: Internal reliability assesses the consistency of results across items within a test. Our examination of the indicator loadings of the models showed that they were all above the recommended value which is 0.7 [32].
ii. **Internal Consistency**: We assessed the internal consistency and reliability using composite reliability (CR) and Cronbach's alpha and all were higher than their threshold value of 0.7 [32]. The composite reliability and Cronbach's alpha is used to analyze the strength of each indicator's correlation with their variables.
iii. **Convergent Reliability**: Convergent relaibilty refers to how closely each variable is related to other variables and other measures of the same construct. We also checked the data for convergent reliability by assessing average variance extracted (AVE) by the variables from its indicator items and all constructs have an AVE above the recommended threshold of 0.5 [32].
iv. **Discriminant Validity**: The Discriminant validity test is used to show that two measures that are not supposed to be related are in fact, unrelated. We assessed discriminant validity using the Heterotrait-Monotrait (HTMT) ratio of correlations and found that HTMT was all below the recommended limit of 0.9 [32].

The measurement models yielded an acceptable value of all indices for PLS model validity and reliability. The tables in the Appendix D show the Cronbach's alpha, Composite Reliability, AVE, and HTMT values of the model for the three framing types.

6.4 Results

In this section, we present the result of the analysis of the data collected in our study.

6.4.1 The Effectiveness of the Persuasive Game Across Game Framings

To answer RQ5a *(What is the perceived effectiveness of the persuasive game overall and the individual persuasive strategies implemented in the game across the three game framings?)*, we verified the effectiveness of the game versions and the persuasive strategies implemented, using a one-sample t-test. This t-test was performed on the mean score of the user ratings of each game version and persuasive strategies, with a reference to the neutral point of 4 on a 7-point persuasiveness scale.

The findings indicated that all versions of the game and all the persuasive strategies implemented were perceived to be significantly effective – gain framing ($t(124)=25.171$, $p<.001$), loss framing ($t(121)=26.483$, $p<.001$), gain-loss framing ($t(122)=24.779$, $p<.001$). Furthermore, all the persuasive strategies deployed within the game were perceived as significantly effective across all framing types, as illustrated in Table 28 and Figure 44.

Table 28. T-Test of the mean values of the three-game versions and the persuasive strategies implemented. (All means were significant at p<.0001, test value = 4).

	Gain Framing				**Loss Framing**				**Gain-Loss Framing**			
	df = 124				**df = 121**				**df = 123**			
Strategies	**M**	**SD**	**t**	**p**	**M**	**SD**	**t**	**p**	**M**	**SD**	**t**	**p**
Reward	5.15	.7706	16.71	.001	5.349	.7600	19.61	.001	5.48	.9396	17.41	.001
Competition	5.14	.9369	13.65	.001	5.170	.8122	15.92	.001	5.40	.9511	16.31	.001
Praise	4.95	.7945	13.31	.001	5.026	.8903	12.73	.001	5.05	.7976	14.65	.001
Suggestion	5.04	.8429	13.82	.001	5.161	.8623	14.87	.001	5.05	.8356	13.96	.001
Overall	5.07	.476	25.17	.001	5.18	.491	26.48	.001	5.25	.557	24.78	.001

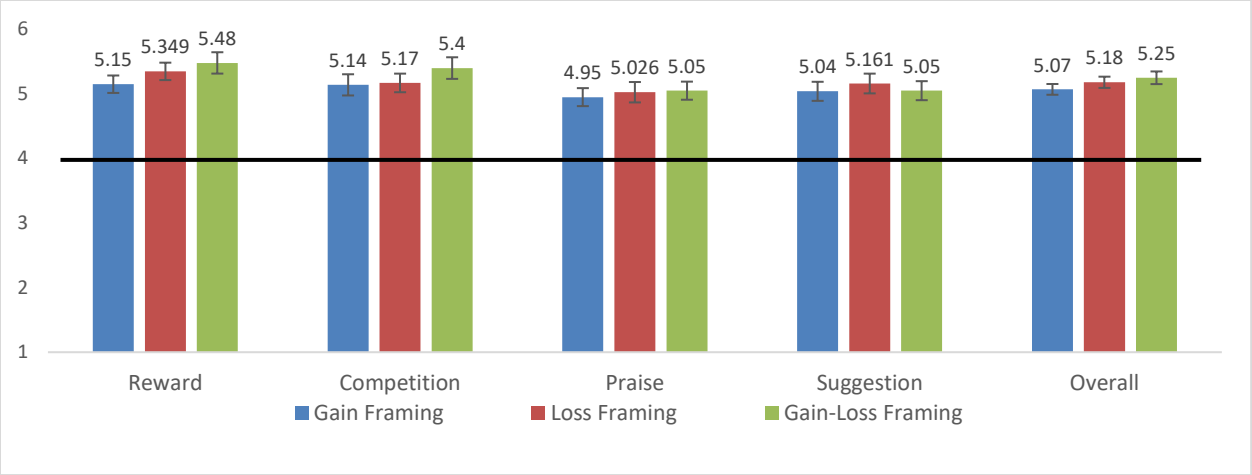

Figure 44 - A bar chart showing the perceived effectiveness of the game overall and its persuasive strategies, across the three game framings.

To answer RQ5b *(Are there any differences in the effectiveness of the persuasive game versions and the persuasive strategies across the three game framings?)*, we conducted a repeated measure ANOVA on the mean ratings of the persuasiveness of the game across the three framing types versions with framing types as the between-subject factor and the strategies as the within-subject. Our results showed that there was a significant main effect of the framing type on the effectiveness of the games overall: $F(2,242) = 3.334$, $p = 0.037$, $\eta 2 \geq 0.027$). Furthermore, a post-hoc pairwise comparison revealed that there was a significant difference in effectiveness between the gain-framed version and the gain-loss-framed version, indicating that the gain-loss-framed version was perceived as significantly more effective than the gain-framed version ($p<.035$). However, there was no statistically significant difference between the loss-framed and the gain-loss-framed version and between the loss-framed version and the gain-loss-framed version.

Similarly, we explored the differences in the effectiveness of the individual persuasive strategies implemented in the games, across the game versions. We conducted a repeated measure ANOVA on the mean ratings of the four persuasive strategies (Reward, Competition, Praise, and Suggestion) across the three framing types, with framing types as the between-subject factor and the strategies as the within-subject. The analysis demonstrated that only the Reward strategy showed a significant main effect across the three game framing versions: ($F(2,242) = 4.414$, $p = 0.013$, $\eta 2 \geq 0.035$). Furthermore, a post-hoc pairwise comparison of the Reward strategy also revealed that

there was a significant difference in the effectiveness of the strategy between the gain-framed version and the gain-loss-framed version. This result reveals that the gain-loss-framed version was perceived as significantly more effective than the gain-framed version ($p<.013$). Surprisingly, no significant difference emerged between the loss-framed and gain-framed versions and between the loss-framed and gain-loss-framed versions.

The non-significant outcomes from our comparative analysis for the competition, praise and suggestion strategies across the three framings imply that these strategies are equally effective irrespective of the framing type; the persuasive strategies were generally effective. In other words, the impact of these strategies remained generally consistent and unaffected by the specific framing employed in the game design.

6.4.2 Relationship between the gamer types and persuasive strategies

To answer RQ5c *(What are the relationships between gamer types and the effectiveness of persuasive strategies in three game versions?)*, we analyzed the relationships between the gamer types and the four persuasive strategies across the three game framing versions. We achieved this using structural models [152]. These structural models determined the relationship between the six gamer types and the persuasiveness of the strategies (see Figure 43). An important criterion to measure the strength of relationships between variables in structural models is to calculate the level of the path coefficient β (which measures the influence of one variable on another), and the significance of the path coefficient, p[63]. The values of the significant path coefficients across the three game framing versions can be seen in Table 29.

Table 29. Standardized path coefficients and significance of the models for the game versions. Bolded coefficients are $p<.001$, non-bolded are $p<.05$ and '-' represents non-significant coefficients, where negative values represent demotivation and positive values represent motivation.

	Gain framing						**Loss framing**						**Gain-Loss framing**					
	Ach	Dis	Fre	Phi	Pla	Soc	Ach	Dis	Fre	Phi	Pla	Soc	Ach	Dis	Fre	Phi	Pla	Soc
REWD	0.36	0.24	0.31	0.34	0.28	0.32	0.22	-	-	-	-	-	0.31	-	-	0.08	-	0.18
COMP	-	-	-	-	-	-	0.26	-	0.17	-	-	0.16	0.27	-	-	-	-	-
PRAS	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04	-	-	0.16	0.04
SUGG	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
REWD = Reward, COMP = Competition, PRAS = Praise, SUGG = Suggestion																		

Ach=Achiever, Dis = Disruptor, Fre = Free Spirit, Phi = Philanthropist, Pla = Player, Soc = Socializer

For the gain-framed version, the results from the structural model showed that the reward strategy significantly influences people belonging to all gamer types. However, the other strategies showed no significant relationships with any gamer type in this game-framed version.

For the loss-framed version, the results show that the reward strategy significantly motivated the people high in the achiever gamer type. Furthermore, the competition strategy positively influences people high in the achiever, free spirit, and socializer gamer type. The other strategies showed no significant relationships with the gamer types in this loss-framed version.

Interestingly, for the gain-loss framing, the reward strategy significantly influenced people high in the achiever, philanthropist, and socializer gamer types. However, the competition strategy significantly influenced people high in the achiever gamer type, while the praise strategy significantly influenced people high in the disruptor, player and socializer gamer type.

We discuss these results in more detail in Section 7.4 of this thesis.

CHAPTER 7 Discussions

In this chapter, we discuss the results from the four previous chapters. We begin by discussing the results pertaining to the impact of application domain on the effectiveness of persuasive strategies, followed by the impact of game framing on the effectiveness of persuasive strategies. Then we discuss the result of the relationship between the effectiveness of the persuasive strategies and their motivational appeal across game framings. Then we conclude by discussing the results about the impact of game framing on the effectiveness of persuasive strategies across different gamer types.

7.1 Discussion on Persuasive strategies and Application domain

In this section, we present a discussion on the results of our study (Chapter 4) which investigates the differences in the perceived effectiveness of persuasive strategies in behaviour change games across two application domains: healthy eating and STD awareness, within each framing type.

7.1.1 Gain Framing across Domains

In this section, we discuss the results of our study as they pertain to gain framing across two application domains: healthy eating and STD awareness. Our analysis reveals significant insights into how gain-framing influences the perceived effectiveness of persuasive strategies within these distinct contexts.

7.1.1.1 Gain Framing across Domains

Our result showed that the healthy eating persuasive game was perceived as significantly more effective than the STD awareness persuasive game. This indicates that the application domain substantially impacts the perceived effectiveness of gain-framed games. Specifically, participants rated the healthy eating version significantly higher than the STD awareness version. This finding underscores the importance of context in persuasive game design. Healthy eating, as a domain, might present more immediate and tangible benefits, making the gain-framing more effective. This aligns with Fogg's Behaviour Model, which highlights the role of perceived benefits in behaviour change [50].

7.1.1.2 Persuasive Strategies in Gain-Framing

Our results also showed that Reward, Competition, and Praise strategies are more effective in certain domains when combined with gain-framing. Participants favoured these strategies in the healthy eating version over the STD awareness version. This could be because gain-framing in healthy eating contexts highlights immediate rewards, such as better health and physical appearance, which are readily appreciated and motivating [68]. In contrast, the benefits of STD awareness might be perceived as less immediate and more abstract, reducing the impact of these strategies.

Interestingly, the suggestion strategy did not show significant main effects across domains. This suggests that the perceived effectiveness of suggestions is consistent across different domains, indicating its broad applicability. The universality of the suggestion strategy might be due to its inherent nature of providing non-intrusive recommendations, which can be equally valuable in various contexts [112].

7.1.2 Loss Framing

In this section, we discuss the results of our study as they pertain to loss framing across two application domains: healthy eating and STD awareness. Our analysis reveals significant insights into how loss-framing influences the perceived effectiveness of persuasive strategies within these distinct contexts.

7.1.2.1 Loss Framing across domains

Our result showed that the STD awareness persuasive game was perceived as significantly more effective than the healthy eating persuasive game in this framing type. This also indicates that the application domain significantly affects the perceived effectiveness of loss-framed games. Specifically, participants rated the STD awareness version significantly higher in perceived effectiveness compared to the healthy eating version. This finding aligns with previous research suggesting that loss-framing, which emphasizes avoiding negative outcomes, may be more compelling in contexts perceived as high-risk, such as STD awareness [160]. In contrast, the

healthy eating domain, which might not be seen as immediately threatening, may not benefit as much from loss-framing.

7.1.2.2 Persuasive Strategies in Loss-Framing

Our results showed that participants favored the reward and competition strategies in the STD awareness version over the healthy eating version in this framing type. This suggests that in high-stakes contexts, such as STD awareness, strategies that emphasize tangible rewards and competitive elements may be more effective in motivating behaviour change. Previous studies have shown that individuals are more responsive to loss-framed messages in high-risk situations, making reward and competition strategies more impactful in such contexts [143].

Interestingly, the praise strategy showed a different pattern. Participants favoured the praise strategy in the healthy eating version over the STD awareness version. This could be because praise, which often serves as a form of positive reinforcement, may resonate more in domains where the behaviour change is seen as less critical and more within personal control [39]. In the context of healthy eating, where changes can be gradual and personally satisfying, praise can be particularly motivating.

The suggestion strategy did not show significant main effects of domains in this framing type indicating that its perceived effectiveness does not vary significantly between the application domains. This consistency suggests that suggestions, which provide non-intrusive recommendations, may be broadly applicable across different contexts. This aligns with the Persuasive Systems Design (PSD) model, which highlights the universal appeal of the suggestion strategies due to their low-pressure nature [112].

7.1.3 Gain-Loss Framing

In this section, we discuss the results of our study as they pertain to gain-loss framing across two application domains: healthy eating and STD awareness. Our analysis reveals significant insights into how gain-loss-framing influences the perceived effectiveness of persuasive strategies within these distinct contexts.

7.1.3.1 Gain-Loss Framing across Domains

Our findings indicate a significant difference in the overall perceived effectiveness of behaviour change games across the two domains when framed for gain-loss, with the healthy eating version being rated more favourably than the STD awareness version. This aligns with previous research suggesting that the context in which persuasive technologies are applied can significantly impact their effectiveness [85]. The higher effectiveness of the healthy eating game could be attributed to the more immediate and personally relevant benefits associated with healthy eating behaviours compared to the perceived stigma and sensitive nature of STD awareness [50]. This result is also consistent with our previous study on persuasive application prototypes which compared the effectiveness of a healthy eating persuasive application to a smoking cessation application [103]. The result showed the healthy eating application to be more effective than the smoking cessation version.

7.1.3.2 Persuasive Strategies in Gain-Loss-Framing

We further examined the effectiveness of persuasive strategies: Reward, Competition, Praise, and Suggestion, across the two domains in this framing type. Significant differences were found in the perceived effectiveness of the Reward and Competition strategies across domains. Participants favoured these strategies more in the healthy eating version than in the STD awareness version. This is consistent with findings from Hamari et al. [68], who noted that rewards and competitive elements are particularly effective in health-related interventions where the outcomes are more tangible and immediate. The Reward strategy's higher effectiveness in the healthy eating context could be due to the direct and immediate gratification it provides, which is less apparent in the context of STD awareness where the benefits of behaviour change may be perceived as more abstract or long-term [148]. Similarly, Competition may drive more engagement and motivation in contexts where individuals can compare their progress and achievements more concretely, as is often the case with healthy eating and fitness goals [65].

In contrast, the Praise and Suggestion strategies did not show significant differences in perceived effectiveness across the two domains. This suggests that these strategies may be universally

applicable, regardless of the application context. Praise, which provides positive reinforcement, and Suggestion, which offers recommendations for behaviour change, appear to be broadly effective and do not rely heavily on the specific nature of the behaviour being targeted. These findings suggest that while some strategies need to be tailored to specific contexts, others can be implemented uniformly across different domains.

7.1.4 Discussion Conclusion

In conclusion, this study provides valuable insights into the perceived effectiveness of persuasive strategies across application domains. In a study of 371 participants, we explored the effectiveness of four persuasive strategies (reward, competition, praise and suggestion) across two application domains (healthy eating and STD awareness), with three framing types (gain-framing, loss-framing, gain-loss-framing).

These results have important implications for the design and implementation of persuasive technologies. For designers and practitioners, it is crucial to consider the context in which a persuasive strategy will be deployed. Strategies such as Reward and Competition should be tailored to domains where they are most effective, such as health and fitness applications. Meanwhile, universally effective strategies like Praise and Suggestion can be applied more broadly, simplifying the design process for applications spanning multiple domains.

Moreover, these findings highlight the need for further research to explore the underlying mechanisms that drive the effectiveness of different persuasive strategies in various contexts. Understanding these mechanisms can inform the development of more context-sensitive persuasive interventions.

7.2 Discussions on Persuasive Strategies and Game Framing

In this section, we discuss the results concerning the significance of persuasive games across different game framings and the effectiveness of the implemented persuasive strategies (Chapter 5). Through this discussion, we aim to provide a comprehensive understanding of the impact of game framing and persuasive techniques on player perceptions and behaviours.

7.2.1 Persuasive Strategies and Persuasive Game Framing

According to our results, one of the key reasons behind the heightened effectiveness of the reward strategy in loss framing could be the psychological phenomenon known as loss aversion. According to Kahneman[79], loss aversion suggests that people tend to place a higher value on avoiding losses than on acquiring equivalent gains. People often do not want to lose what they already have even if they can acquire a new one. In the context of persuasive games, players exposed to loss framing may be more impacted by the potential negative consequences of failing to achieve the desired behaviour. Hence, the appeal of rewards as an incentive for adhering to actions that prevent losses becomes especially compelling, serving as an effective strategy to avert these perceived drawbacks. This is evident from the following comments:

'The fear of losing all Pacman's life keeps me on my toes and adds a [unique] level of excitement!' – P46 (LF)

'…Whenever I have just one life remain[ing], it always makes me anxious of losing the game….' – P102 (LF)

Furthermore, Loss framing can create a sense of urgency and heightened motivation in players. When faced with the prospect of negative outcomes, individuals often experience increased motivation to take actions that mitigate those potential losses [61]. In the context of our persuasive game, players encountering loss framing may be more motivated to engage, collect rewards, and compete with others as a means of averting undesirable consequences related to failing to adopt healthy eating habits. This is evident from the following comment:

"I never thought losing my life would motivate me to avoid the junk food in the game. It drove me to try to stay alive till the end". – P101 (LF)

Another reason for the stronger effectiveness of rewards in loss-gain framing may be due to 'incentive salience'[24]. This refers to the motivational 'pull' of rewards. In a loss-framed game, rewards are perceived as valuable incentives that help players avoid negative outcomes (losses). The emotional response to avoiding a loss through a reward can be more intense and motivating,

leading to increased player engagement and persistence. It is also evident in the participant's comment below.

"Every badge felt like a small victory in the game. I wish I could be rewarded for avoiding burgers in real life. Lol." – P15 (LF)

The significant effectiveness of the competition strategy in loss framing over gain framing can be attributed to the fact that loss framing frequently triggers social comparison tendencies [58]. Therefore, in loss-framed games, players may tend to compare themselves with other players, striving to maintain or improve their social status. This competitive comparison motivation is likely stronger in loss contexts, making competition very effective. Furthermore, loss-framed persuasive games activate the fear of losing something valuable, intensifying individuals' competitive drive to avoid losses[165]. In this case, the competition strategy becomes a powerful motivator in loss-framed situations, as individuals are driven to climb to the top of the leaderboard to prevent negative outcomes.

Our result showed that there was no significant difference in the effectiveness of the praise and suggestion strategy across the framings. One plausible explanation for the lack of significant differences in the effectiveness of praise across different framings could be attributed to the 'inherent positivity bias' associated with praise [23]. This bias suggests that regardless of the framing context, positive reinforcements like praise inherently carry a strong motivational impact, often overshadowing the framing effects. In both loss and gain-framing, the positive nature of praise could overshadow the framing effect, leading to similar outcomes. Furthermore, praise is a social norm in many cultures, and individuals might respond similarly to praise irrespective of the framing [96]. Social expectations and norms related to positive feedback might override framing effects.

A plausible reason for the lack of difference in the effectiveness of the suggestion strategy between loss and gain framing contexts is rooted in the nature of suggestion strategies. These strategies typically aim to influence behaviour by suggesting small, easy-to-achieve actions. In both loss and gain framing, these suggestions might align seamlessly with individuals' existing beliefs and

behaviours, fostering cognitive consistency [48] Also, since suggestions often empower individuals to make their own choices, enhancing their perceived autonomy, a crucial factor in motivation[145]. Regardless of framing, the autonomy provided by suggestion strategies might lead to similar outcomes, as individuals feel in control of their actions.

7.2.2 Benefits of Combining Loss and Gain Framing in Persuasive Games

Although our result showed that persuasive loss game framing is more effective than gain-framed game, it also demonstrated that the combined use of loss and gain framing is more effective than employing each individually. This is likely because Gain-Loss framing allows the game to appeal to a broader audience. Some individuals may respond more positively to gain-framed messages that highlight potential benefits and rewards, while others may be motivated by loss-framed messages that emphasize avoiding negative consequences. Combining both approaches ensures that persuasive game messages resonate with a wider range of people.

Furthermore, Gain-loss framing creates a more balanced and comprehensive persuasive message. It provides a more holistic view of the decision-making process in real life by addressing the positive and negative aspects of the consequences of our choices. Unlike loss framing where users see only the negative aspects, or gain framing where users see only the positive side. This can lead to more informed and deliberate behaviour change decisions. Gain-loss-framing also encourages players to consider a broader range of options and outcomes, which promotes a more flexible approach to decision-making, where people weigh the pros and cons before taking action. This can be particularly useful in complex decision scenarios.

Gain-loss framing also opens up possibilities for additional game design functionalities and features and gives more flexibility to the designer. We noticed that while designing the game mechanics for loss framing and gain framing individually, we felt constrained and restricted in design choices with respect to how to design the specific elements of each framing. Conversely, while designing the gain-loss version, we experienced greater flexibility and freedom. This was because we could integrate all aspects of healthy eating, whether focusing on potential losses or gains, more seamlessly. Moreover, this flexibility not only enhances the persuasive elements of

the game but also leads to the design of more exciting and engaging gameplay experiences for the players. By incorporating both gain and loss aspects, game designers can craft dynamic challenges and rewards, making the overall gaming experience more immersive and enjoyable for the players.

7.2.3 Discussion Conclusion

In the evolving landscape and increasing development and use of games as persuasive technology and behaviour change tools, the role of game framing in the design and implementation of persuasive games has emerged as a pivotal factor. We explored the interaction between game framing and the effectiveness of persuasive games, using the context of a persuasive game focused on healthy eating. Specifically, in our study and analysis, we examined the impact of gain-framing, loss-framing, and gain-loss framing on the effectiveness of a persuasive game and the strategies implemented within the game.

In summary, it is evident that the effectiveness of persuasive games truly hinges not only on their engaging gameplay mechanics but also on the strategic framing of their content. Persuasive game designers should recognize the power of game framing as a persuasive tool, capable of eliciting meaningful changes in player behaviour and attitudes.

However, it is essential to acknowledge the context-specific nature of our findings. The dynamics of game framing efficacy may differ across diverse domains and target populations. Thus, future research should continue to explore and refine the application of game framing principles in persuasive game design. We also acknowledge that other confounding factors could contribute to the effectiveness of persuasive games in the various game framing. These include personality, motivational appeal and play experience.

7.3 Discussions on the relationship between Motivational Appeal and Persuasive Strategies across Game Framings

In this section, we will discuss the results concerning the motivational appeal of persuasive strategies implemented in persuasive games across different game framings (Chapter 5). Through this discussion, we aim to provide a comprehensive understanding of the impact of game framing and persuasive techniques on players' motivation.

Since our findings show many significant differences in motivational appeal across game framing, therefore it is important that persuasive game designers meticulously tailor persuasive strategies to align with specific framing contexts. For instance, in gain-framed scenarios, where positive outcomes are emphasized, strategies like reward, praise, and suggestion can be particularly effective in capturing attention and boosting confidence. However, in loss-framed contexts, where potential negative consequences are highlighted, adapting these strategies to emphasize resilience and overcoming challenges may enhance their motivational impact.

7.3.1 Confidence

Our findings reveal a consistent pattern: *Confidence* emerged as a factor that showed significant association with all the persuasive strategies across various game framing types. This uniform significance underscores the central role that confidence plays in shaping player motivation within the context of behaviour change games. Regardless of the framing—whether emphasizing gains, losses, or a combination of both—the pivotal influence of confidence remains evident, highlighting its universal importance in driving player engagement and fostering positive behaviour change. Confidence, closely tied to the concept of self-efficacy, reflects an individual's belief in their ability to successfully execute specific tasks or behaviours [14]. The fact that confidence remains significant across various persuasive strategies suggests that it is a common thread influencing player motivation in multifaceted ways. Players are more likely to be motivated when they feel confident in their capacity to meet the challenges presented in the game and achieve positive outcomes. For persuasive game designers, recognizing the universal significance of confidence opens avenues for intentional design choices. Strategies that actively boost players' confidence, such as providing positive feedback, acknowledging achievements, and offering personalized support, can contribute to a more motivating and engaging gaming experience when employed in behaviour change games. Additionally, creating game scenarios that gradually build and reinforce players' confidence levels can enhance the effectiveness of behaviour change interventions.

7.3.2 Attention

Attention showed the highest number of stronger significance associations with the strategies across the game framing types. This underscores its pivotal role as a driving force behind player

motivation and engagement within behaviour change games. Given the central role of attention, persuasive game designers are urged to prioritize strategies explicitly designed to capture and, crucially, sustain players' attention throughout the entirety of the game play. The success of behaviour change interventions hinges on the ability to maintain players' focus, ensuring that the intended persuasive messages are not only noticed but also retained and internalized. To achieve this, designers can employ a range of effective techniques. Engaging visual cues, carefully crafted interactive elements, and well-timed interventions all play essential roles in capturing and maintaining attention. Visual stimuli that are aesthetically pleasing and aligned with the game's theme can draw players into the narrative, creating a more immersive experience. Interactive elements, such as gamified challenges or decision-making scenarios, actively involve players, fostering a sense of agency and investment. Additionally, well-timed interventions, strategically placed within the gameplay, can serve as effective nudges, redirecting attention towards key messages or behaviour prompts. By prioritizing attention, designers can optimize the deployment of persuasive strategies, ensuring that they resonate with players on a cognitive and emotional level. The goal is to create an environment where players not only notice the persuasive elements but also find them compelling and relevant. This heightened attention, when sustained, increases the likelihood of players internalizing the intended behaviour change, thereby enhancing the overall impact of the behaviour change game.

7.3.3 Satisfaction

Interestingly, our overall findings showed that Satisfaction had the second highest number of stronger significant association with the persuasive strategies across the game framing types. This implies that satisfaction is a crucial metric, reflecting players' contentment, enjoyment, and fulfilment derived from their gaming experiences. This finding also prompts an exploration into how satisfaction interplays with persuasive strategies, shedding light on its role in shaping player engagement and ultimately driving positive behaviour change. The prominence of satisfaction suggests that players are not solely motivated by the immediate impact of persuasive elements but are deeply influenced by their overall sense of gratification and enjoyment derived from the game – either from the design aesthetics, interactive features, and the overall gaming journey.

Understanding the significance of satisfaction becomes pivotal in tailoring behaviour change interventions that extend beyond the immediate persuasive cues, considering the holistic gaming experience. Given its notable impact, game designers are encouraged to strategically incorporate elements that contribute to player satisfaction. Persuasive strategies such as badges, leaderboards, praise, and gameful suggestions, which have demonstrated stronger significance, can be further refined and optimized to enhance the overall satisfaction of players. For example, badges and leaderboards can be designed not just as markers of achievement but as elements that contribute to a sense of accomplishment and progress. Positive reinforcement through praise and well-timed suggestions can be woven seamlessly into the gameplay, creating moments that elevate player satisfaction. Moreover, understanding the dynamics of satisfaction across different game framing types is essential. Designers can tailor their approaches based on whether the content is gain-framed, loss-framed, or a combination of both. Recognizing the unique preferences and sensitivities of players within each framing context allows for the customization of persuasive strategies to maximize satisfaction.

7.3.4 Relevance and Suggestion Strategy

Relevance, as a key motivational dimension, demonstrated significant relationships with various persuasive strategies, with a notably strong association with the suggestion strategy across all the game framing versions. This finding suggests that, regardless of the framing scenarios, suggestions play a pivotal role in aligning the persuasive message with the perceived relevance of the content. The suggestion strategy emerges as a potent tool for making the game content personally meaningful and pertinent to the player, enhancing its overall relevance. The consistent significance of relevance across different framing conditions further emphasizes its importance in shaping player motivation. Understanding the nuanced dynamics of relevance allows for the strategic tailoring of persuasive interventions to maximize their impact. Designers can leverage the suggestion strategy, especially within gain-framed contexts, to enhance the perceived relevance of the content and increase its motivational appeal. In practical terms, these findings offer valuable insights for persuasive game designers aiming to optimize the motivational appeal of behaviour change interventions. By strategically incorporating suggestion elements, designers can create

interventions that resonate with players on both cognitive and emotional levels. This may involve implementing well-timed and contextually relevant suggestions that align with the framing context of the game, ensuring that they contribute meaningfully to the overall motivational experience.

7.3.5 Discussion Conclusion

In conclusion, this study aimed to explore the impact of game framing on the relationship between the effectiveness of four popular persuasive strategies (reward, competition, praise, suggestion) and their motivational appeal in a persuasive game for healthy eating across the three different game framings. We found significant perceived effectiveness of all persuasive strategies within each game-framing version. Our results also highlighted the significant impacts of game framing on the relationship between the effectiveness of persuasive strategies and their motivational appeal.

Our findings underscore the importance of tailoring persuasive strategies to intensify the four motivational appeal dimensions effectively. By understanding how different game framings interact with persuasive strategies, designers can enhance the persuasive appeal of games and promote desired behaviours among users. Our study provides valuable insights for implementing persuasive strategies in game design to optimize motivational appeal and foster engagement. Our results collectively contribute to the growing body of knowledge on the design and optimization of behaviour change games. Designers and researchers alike can draw upon these findings to tailor interventions that not only capture attention and relevance but also foster confidence and satisfaction, ultimately driving sustained motivation for positive behaviour change.

7.4 Discussions on the Impact Game Framings on the Effectiveness of Persuasive Strategies for Different Gamer Types

In this section, we discuss some interesting insights from the results pertaining to game types and persuasive strategies within game-framing types (Chapter 6).

7.4.1 Gamer Types and Persuasive Strategies.

An interesting aspect of our results revealed that the reward strategy had a strong positive relationship with the achiever gamer type in all the framing versions. This implies that people high

in the achiever gamer type are strongly positively motivated by rewards regardless of the game framing type. This is no surprise since achievers are often motivated by a sense of accomplishment and mastery [163]. Rewards can act as acknowledgements of their achievements, providing a tangible representation of their gaming skills and progress. When designing rewards for achievers, we strongly recommend that persuasive game designers implement badges that show gradual mastery of game elements. This would incrementally increase the level of engagement for this gamer type while maintaining their interest.

Interestingly, the praise strategy only showed a significant relationship with participants high in the disruptor, player, and socializer gamer types. This is likely because positive reinforcement, such as praise, has been identified as a powerful motivator by reinforcing positive behaviours and accomplishments [38]. Whether it's recognizing a disruptor's creative approach, a player's competitive success, or a socializer's achievements in the gaming community, praise fosters a sense of achievement.

Similarly, the free-spirit gamer type showed a significant relationship with competition strategy in the loss-framed version. Free spirits, identical to explorers, are known for their love of exploration, variety, and new experiences in gaming [69]. In loss-framed games, which emphasize challenges and obstacles, individuals with a high free spirit gamer type may find the competitive elements more engaging and stimulating. The competitive strategy, which introduces challenges and rivalries, aligns with the free spirit's desire for variety and excitement. We recommend that persuasive game developers integrate dynamic challenges tied to leaderboards to enhance engagement for free spirits.

Another interesting result is that the philanthropists only showed a significant relationship with the reward strategy in the gain-framed and the gain-loss-framed versions. This may be because philanthropists are driven by a sense of purpose and meaning [163]. Using rewards in games gives players clear goals, making the game feel purposeful and meaningful. This connection encourages players to stay engaged, potentially leading to positive outcomes. Persuasive game designers can leverage this understanding when creating games for philanthropists. By implementing rewards that carry personalized meanings to the player, designers can forge a deeper connection to the

player's sense of purpose and meaning. Additionally, incorporating rewards with incrementally staged goals can sustain the philanthropist player's interest, keeping them motivated and eager for more purposeful experiences within the game. This tailored approach enhances player engagement and aligns with the intrinsic motivations of philanthropist gamers.

The socializer gamer type showed a significant positive relationship with reward strategy in the gain-framed version, competition in the loss-framed version and reward and praise in the gain-loss-framed version. A reason why socializers may be influenced by competition strategies such as leaderboards is that they often thrive on social interactions and comparisons[163]. Leaderboards provide clear platforms for comparing one's performance with that of others, fostering a sense of status and accomplishment. Socializers may be motivated to engage more actively in the game to improve their leaderboard standings and showcase their achievements to their social circle. To enhance the persuasiveness of games designed for socializers, we propose incorporating game goals and elements that are closely linked to interactions with other gamers. This strategic integration aligns with the motivational preferences of socializers, leveraging the potent influences of social interaction, such as comparisons and recognitions, to foster a more persuasive gaming experience. By emphasizing these aspects, persuasive games can tap into the inherently social nature of socializers, making the gameplay more engaging and compelling for this gamer type.

7.4.2 Other Discussions

The absence of significant negative path coefficients in any of the versions indicates that there were no discernible demotivational factors for any of the gamer types across the different framings. Consequently, none of the four strategies employed can be identified as a strong demotivating factor for any specific gamer type. This absence of negative consequences suggests that these strategies can be implemented without concern, underscoring their potential for positively influencing gamer types.

Also, the suggestion strategy showed no significant relationships with any of the game types across all framing types. This is understandable due to the nature of the suggestion strategy. This strategy generally targets behaviour change by recommending small, easily attainable actions. Whether

employing loss, gain or gain-loss framing, these recommendations tend to harmonize effortlessly with individuals' pre-existing beliefs and behaviours, thereby promoting cognitive consistency [48]. Additionally, as suggestions often empower individuals to make independent choices, thereby enhancing their perceived autonomy, this becomes a critical motivator [145]. Despite the framing employed, the autonomy afforded by suggestion strategies could result in comparable outcomes, fostering a sense of control over their actions among individuals.

Interestingly the reward persuasive strategy had the highest number of significant relationships with the gamer types across the three framing versions. This shows the versatility of the reward strategy as a very strong strategy in promoting behaviour change, especially in the healthy eating domain. Persuasive game designers should endeavour to employ rewards as often as possible when creating persuasive games. The fact that the reward strategy resonates with various gamer types suggests a broad appeal. Different gamers may have diverse preferences, motivations, and playstyles, but the common thread of responding positively to rewards highlights the generalizability of this strategy. This versatility is crucial for persuasive game designers, as it allows them to craft experiences that cater to a wide audience. Also, research has shown that the use of rewards aligns with well-established psychological principles, such as reinforcement and positive reinforcement, which can significantly impact player behaviour. The relationship between reward strategies and the gamer types further underscores the broad appeal and effectiveness of this approach across diverse player preferences.

7.4.3 Discussion Conclusion

In conclusion, Chapter 6 explored the relationship of gamer types, game framing, and persuasive strategies within the context of a healthy eating persuasive game. While persuasive games have demonstrated efficacy in behaviour change, our study sheds light on some factors influencing their effectiveness. The examination of three game-framing versions and four persuasive strategies revealed that all strategies were perceived as effective, with the reward strategy standing out as significantly different across framing types. Notably, the reward strategy had the most consistent and significant relationships with all gamer types across various game framings, emphasizing its

broad appeal and potential to motivate diverse player preferences. Conversely, suggestions showed no significant relationships with gamer types across all framings.

These findings offer valuable insights for persuasive game designers, suggesting that an understanding of gamer types and their responsiveness to specific strategies is paramount. Moving forward, these results highlight the importance of reevaluating persuasive game design principles. We urge persuasive game designers to consider tailoring their games based on gamer characteristics such as gamer types and considering the choice of framing game content. By leveraging the strengths inherent in this tailored design approach, persuasive games can become more effective in their potential to promote positive behaviour change in players.

7.5 The Final Discussion

The effectiveness of persuasive strategies in games is impacted by an interplay between game framing, application domain, motivational appeal, and gamer types. Each of these factors can influence others, which implies that the success of persuasive games may depend on how well these elements are integrated.

As seen in our results, the interaction of a persuasive game's framing and its application domain can determine the effectiveness of persuasive strategies implemented in the game. For instance, in a game aimed at promoting Healthy Eating, a gain framing that highlights the benefits of consuming nutritious foods may be more effective. On the other hand, in the context of STD Awareness, a loss framing that emphasizes the risks of unsafe behaviours might resonate more strongly with the audience. The interaction between framing and domain suggests that the persuasive impact is maximized when the framing aligns with the inherent characteristics of the domain, making the message more relevant and compelling to the player.

Our study also showed that the motivational appeal of persuasive games can be greatly impacted by their framing. For instance, gain-framed games are very strong in grabbing attention when compared to other game framing. This may imply that gain-framed showing the importance of the behaviour being promoted is significant to gain the attention of players. We also observed that combining gain and loss framing in a game creates the most significant satisfaction in persuasive

games. Understanding how game framing interacts with the motivational appeal of persuasive strategies to be implemented is vital for ensuring that the persuasive games are engaging and motivating, thereby increasing their effectiveness.

The effectiveness of persuasive strategies in games is shaped by the interplay between game framing, application domain, motivational appeal, and gamer types. The success of these strategies relies on how well these factors are aligned and integrated. By carefully considering game framing and the motivational appeal of persuasive strategies as it relates to the application domain, and tailoring strategies to specific gamer types, game designers can create more impactful persuasive games. These games not only engage players but also effectively promote desired behaviours across various contexts and audiences.

CHAPTER 8 Conclusion

In this final chapter, we highlight the limitations and potential future work directions for the P-Gamer platform and the exploration of the effectiveness of persuasive games. Then we conclude by summarizing the research contributions of this research

8.1 Limitations and Future Work

In this section, we discuss some potential future work on the P-Gamer platform and other study directions.

8.1.1 Automated Analysis of collected data.

As part of our future developments for the P-Gamer platform, we aim to extend its capabilities for collecting and analyzing user data. While the current version allows for the collection of demographic data, personality traits, gamer types, and motivational appeal, we envision expanding on these features to encompass a broader range of user data. This may include data related to gameplay behaviour, in-game interactions, decision-making processes, and emotional responses, among others. By incorporating additional types of user data, we can provide researchers with a more comprehensive understanding of player engagement and behaviour within persuasive gaming contexts.

In addition to the data collection functionalities, we intend to equip the P-Gamer platform with robust statistical analysis tools. These tools will enable automated processing and interpretation of the collected data, allowing for real-time insights into user behaviour and preferences. We will leverage advanced statistical techniques, such as ANOVA, correlation analysis, regression modelling, PLS-SEM, and cluster analysis to make the P-Gamer platform a more robust tool for analysing and driving insights about user behaviour. We will also support this by providing interactive visualizations to facilitate data interpretation and implementing customizable reporting features to meet the diverse needs of researchers and practitioners. This will empower researchers to easily uncover meaningful patterns and associations within the dataset without a need for additional tools. Moreover, the automated analysis features will facilitate the generation of

actionable recommendations for optimizing persuasive game design strategies and refining research methodologies.

8.1.2 Inclusion of more game design options

Our current iteration of the P-Gamer platform offers designers a set of predefined game types to choose from when selecting a game concept. While this provides a starting point for persuasive game design, it may limit the creative freedom of designers, as certain persuasive content may not align perfectly with the predefined game structures available in the platform. To address this limitation and empower designers with greater flexibility and customization options, we propose the incorporation of drag-and-drop game design tools in future versions of the platform. This would facilitate more advanced and creative game design processes. Designers will have the freedom to craft better game concepts tailored to their specific persuasive goals and target audience. These tools will enable the creation of custom gameplay mechanics, narrative structures, and interactive elements, empowering designers to experiment with innovative approaches to persuasive game design. It would also foster a culture of creative expression and experimentation among designers. With the ability to implement their own game concepts, designers can unleash their creativity and easily explore unique ways to engage and motivate players towards desired behavioural outcomes. This flexibility will encourage diversity in persuasive game design approaches and foster innovation within the field.

8.1.3 Allow the addition of more persuasive strategies and domains.

Currently, the P-Gamer platform restricts persuasive game designers to implementing only four predefined persuasive strategies, with limited variations for each. This constraint, while suitable for the scope of this research, may limit the versatility and effectiveness of persuasive game design. To address this limitation, we aim to broaden the range of available persuasive strategies in future iterations of the platform. In addition to expanding the selection of persuasive strategies, we plan to offer designers more flexibility in implementing these strategies within their games. Rather than limiting designers to a fixed number of implementation options, we intend to provide a comprehensive library of implementation techniques and mechanics for each persuasive strategy.

This will allow designers to tailor the execution of persuasive strategies to suit the unique requirements of their game concepts and target audience.

While the current version of the P-Gamer platform focuses on two specific problem domains – healthy eating and STD awareness – we recognize the importance of addressing a broader range of societal issues through persuasive gaming interventions. In future iterations, we aim to expand the platform's collection of problem domains to include additional areas such as physical activity promotion, environmental sustainability, smoking cessation, and more.

By incorporating a diverse array of persuasive strategies and problem domains into the P-Gamer platform, we seek to enhance its robustness and applicability across a wide range of contexts. This expansion will enable designers to create persuasive games that address a broader spectrum of behavioural change objectives, catering to the needs and preferences of diverse audiences. Ultimately, this evolution will contribute to the platform's effectiveness as a tool for designing impactful persuasive gaming experiences and fostering positive behaviour change at scale.

8.1.4 Short-term Self-Reported Data

Our study was based on short-term, self-reported data of the participants' perceived persuasiveness of these strategies based on the actual implementations. Previous work shows personalized applications based on self-report were effective in motivating actual behaviour in various domains: eating, eCommerce, snacking, and physical activity [81][117]. Both explicit measures (self-assessment of strategies) and implicit measures (actual responses) are effective approaches to tailoring persuasive applications [81]. However, we acknowledge that the actual persuasiveness of these strategies may differ when implemented in games and used over long periods. Therefore, future research should investigate the long-term effects of persuasive strategies on sustained behaviour change and explore the potential integration of emerging technologies, such as machine learning and artificial intelligence, in enhancing the efficacy of behaviour change games over time.

8.1.5 Repeated Collection of the Same Data

Another limitation of our study is that we collected gamer type and demographic data from each participant during each iteration of the game, resulting in participants filling out this information three times. This repetitive data collection could have led to participant fatigue, potentially affecting the accuracy and consistency of their responses. Additionally, the repetitive nature of the task might have influenced participants' engagement with the game itself, possibly diminishing the ecological validity of the results. Furthermore, the redundancy in data collection could have introduced unnecessary variance in the dataset, complicating the analysis and interpretation of results related to gamer type and demographic influences.

8.2 Contributions

This thesis offers three main contributions that advance the field of Human-Computer Interaction and Persuasive games:

1. **Development of a Domain-Independent Persuasive Game Platform**: We introduced and designed a versatile, domain-independent persuasive game platform investigating the effectiveness and user responses to persuasive strategies (Chapter 3). The platform's usability was evaluated through the design of persuasive games and game studies, demonstrating its effectiveness in creating and assessing persuasive game interventions.
2. **Impact of Application Domain on Persuasive Strategies**: Through a comprehensive large-scale study, we explored how the application domain affects the effectiveness of persuasive strategies (Reward, Competition, Praise, and Suggestion) across two specific domains: healthy eating and STD awareness, using the P-Gamer platform (Chapter 4). This study provided valuable insights into how domain context influences the effectiveness of these persuasive strategies.
3. **Impact of Game Framing on Persuasive Strategies and Motivational Appeal**: We examined how game framing influences the perceived effectiveness of persuasive

strategies and their relationship with motivational appeal within a healthy eating persuasive game generated using the P-Gamer platform (Chapter 5). Our findings revealed that game framing significantly impacts the effectiveness of persuasive strategies. It also showed that game framing influences the relationship between persuasive strategies and motivational appeal dimensions (attention, relevance, confidence, and satisfaction). For example, of the four persuasive strategies, only the Reward and Suggestion strategies maintained a consistent relationship with all motivational appeal dimensions across different game-framed versions.

4. **Effectiveness of Persuasive Strategies Across Gamer Types and Game Framings**: We explored the relationship between the effectiveness of persuasive strategies and gamer types across different game framings (Chapter 6). This investigation revealed some important insights for persuasive game designers, highlighting the need to consider gamer types and game framing in game design. For instance, the Reward strategy showed significant relationships with all gamer types in the gain-framed persuasive game, while the Suggestion strategy did not show significant relationships with any gamer types across all framings.

These findings from our studies shed light on the importance of considering the game framing, motivational appeal, and gamer types in designing more effective persuasive games. By exploring these relationships, we provide valuable insights for researchers, practitioners, and game designers aiming to harness the potential of persuasive gaming interventions for promoting positive behaviour change.

Looking ahead, there is immense potential for further advancements in the field. We outline potential avenues for future research and development to enhance the P-Gamer platform for designing persuasive persuasive games and game studies (Chapter 8). By expanding the platform's capabilities, such as incorporating additional persuasive strategies, diversifying the application domains, and implementing advanced game design options, we can further enrich our understanding of persuasive gaming and its impact on behaviour change.

In conclusion, this dissertation represents a significant step forward in advancing the design of behaviour change games in persuasive technology research. Our contributions provide a robust foundation for future explorations in this evolving field, offering practical tools and insights to enhance the effectiveness of persuasive games in promoting positive behavioural outcomes.

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APPENDIX A. Study Questionnaires

Persuasiveness Questions for Healthy Eating (Gain-Framing)

Question	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
This feature would influence me to eat healthily.							
This feature would convince me to eat healthily.							
This feature would be personally relevant for me.							
This feature would make me reconsider my eating habits.							
The feature would make or motivate me to play the game							

Persuasiveness Questions for Healthy Eating (Loss Framing)

Question	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
This feature would influence me to stop eating unhealthily.							
This feature would convince me to stop eating unhealthily.							
This feature would be personally relevant for me.							
This feature would make me reconsider my eating habits.							
The feature would make or motivate me to play the game							

Persuasiveness Questions for Healthy Eating (Gain-Loss Framing)

Question	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
This feature would influence me to eat healthily and stop eating unhealthily.							
This feature would convince me to eat healthily and stop eating unhealthily.							
This feature would be personally relevant for me.							
This feature would make me reconsider my eating habits.							
The feature would make or motivate me to play the game							

Persuasiveness Questions for STD Awareness (Gain-Loss Framing)

Question	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
This feature would influence me to practice safe sexual behaviours.							
This feature would convince me to practice safe sexual behaviours.							
This feature would be personally relevant for me.							
This feature would make me reconsider my safe sexual behaviours.							

The feature would make me or motivate me to play the game							

Persuasiveness Questions for STD Awareness (Gain Framing)

Question	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
This feature would influence me to practice safe sexual behaviours.							
This feature would convince me to practice safe sexual behaviours.							
This feature would be personally relevant for me.							
This feature would make me reconsider my safe sexual behaviours.							
The feature would make me or motivate me to play the game							

Persuasiveness Questions for STD Awareness (Loss Framing)

Question	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
This feature would influence me to stop risky sexual behaviours.							
This feature would convince me to stop risky sexual behaviours.							

This feature would be personally relevant for me.							
This feature would make me reconsider my safe sexual behaviours.							
The feature would make me or motivate me to play the game							

Persuasiveness Questions for STD Awareness (Gain-Loss Loss Framing)

Question	**Strongly Disagree**	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
This feature would influence me to practice safe sexual behaviours and stop risky sexual behaviours.							
This feature would convince me to practice safe sexual behaviours and stop risky sexual behaviours.							
This feature would be personally relevant for me.							
This feature would make me reconsider my safe sexual behaviours.							
The feature would make me or motivate me to play the game							

Motivational Appeal Questions for Healthy Eating

	Strongly disagree	**Disagree**	**Somewhat Disagree**	**Neutral**	**Somewhat Agree**	**Agree**	**Strongly Agree**
Attention							
1. The system would capture and hold my attention.							
2. The system has some contents that stimulates my curiosity.							
Relevance							
1. The content of the system would be relevant to me.							
2. I can relate with the content of this system.							
3. The content of the system makes sense to me.							
4. The content of the system would be useful to me.							

1. It would be easy to understand and use the system.							
2. The system would help me control my eating behaviour.							
3. The system would build my confidence in my ability to control my eating behaviour.							
1. I would really enjoy using the system.							
2. It would be a pleasure to work with a system like this.							
3. The system would help me							

accomplish my behaviour goal.							

Gamer Type Questions

To what extent do you agree with the following statements?

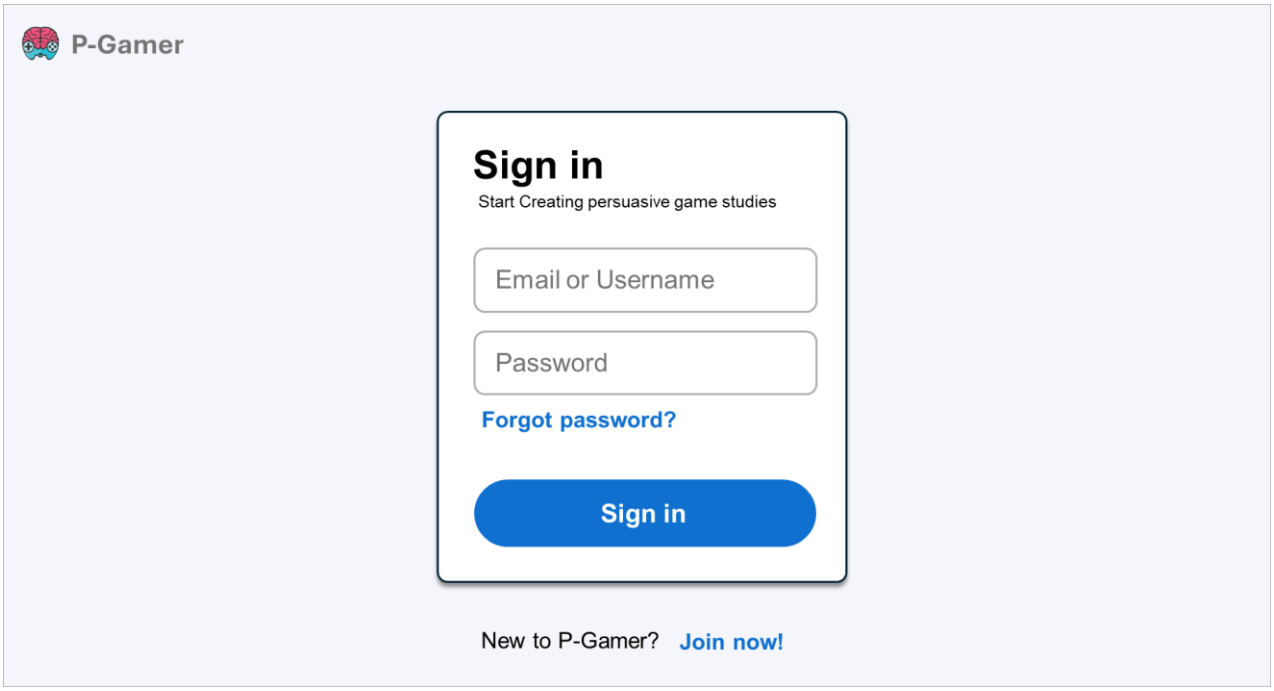
Question	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
Interacting with others is important to me							
It makes me happy if am able to help others.							
It is important to me to follow my own path							
I like being part of a team.							
I like to provoke.							
I am very ambitious							
I like competitions where a prize can be won.							
It is important to me to feel like am part of a community.							

I often let my curiosity guide me.							
I feel good taking on the role of a mentor.							
I like to question the status quo.							
It is more fun to be with others than by myself.							
Rewards are a great way to motivate me							
I like to try new things.							
I like defeating obstacles.							
I look out for my own interests.							
I like helping others to orient themselves in new situations							
I see myself as rebel.							
I enjoy group activities.							

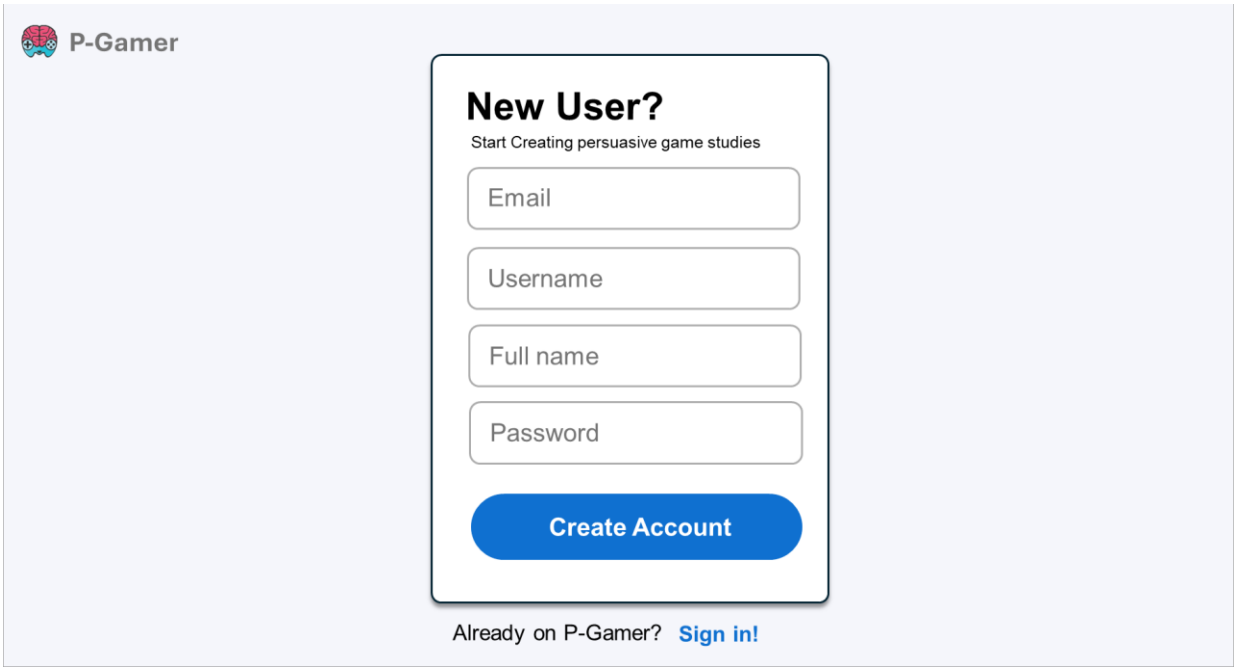
It is important to me to always carry out my tasks completely.							
I prefer setting my own goals.							
I dislike following rules							
I like sharing my knowledge							
It is difficult for me to let go of problem before have found a solution.							
Return of investment is important to me.							
Being independent is important to me.							
I like mastering difficult tasks.							
The well- being of others is important to me.							

I like to take changing things into my own hands.							
If the reward is sufficient I will put in the effort.							

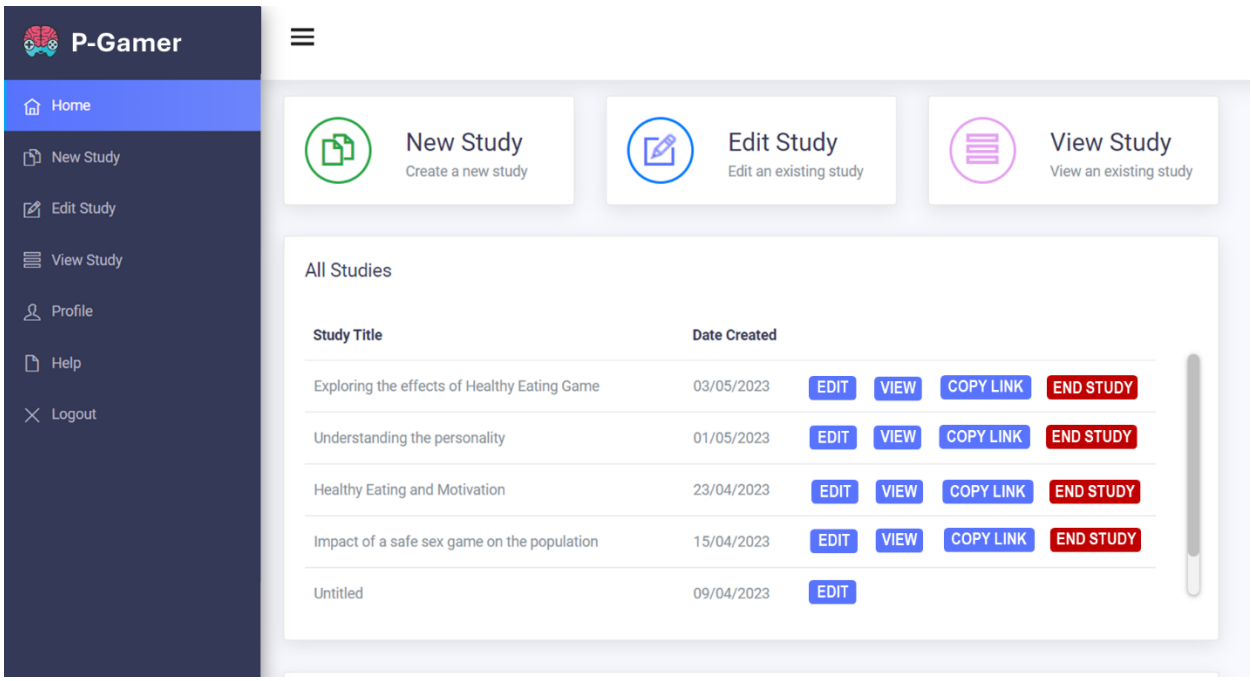
APPENDIX B. P-Gamer Screenshots



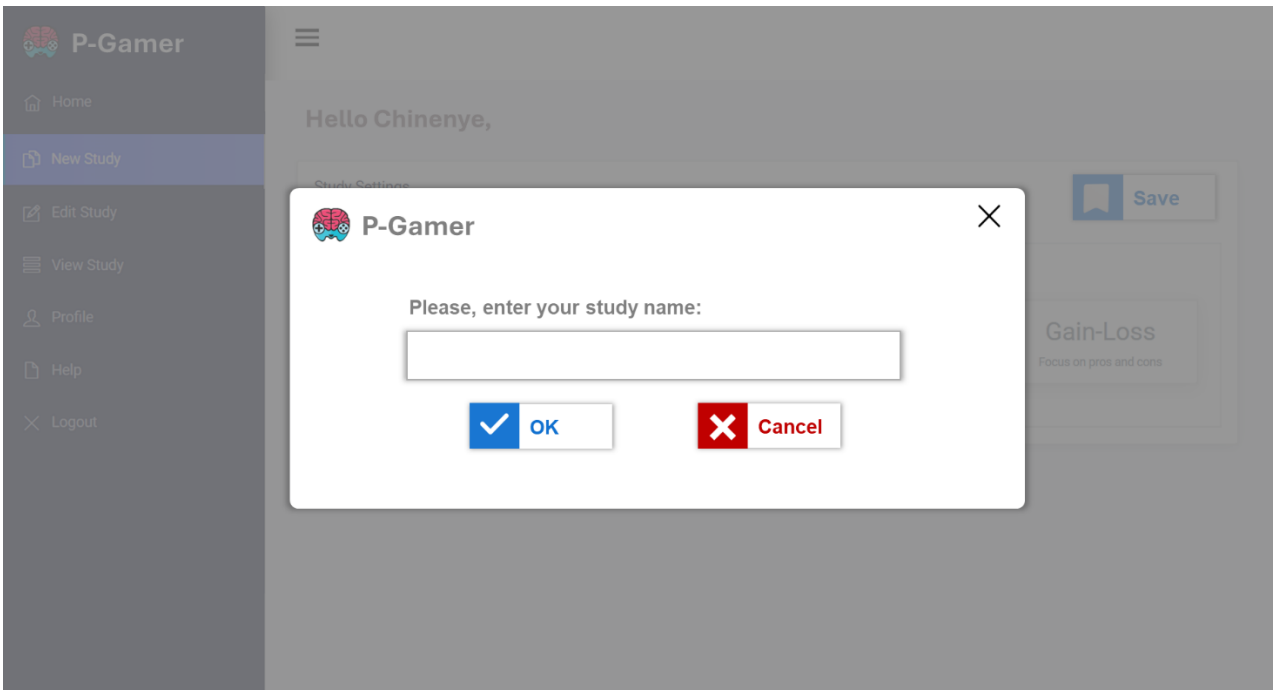
Login Page



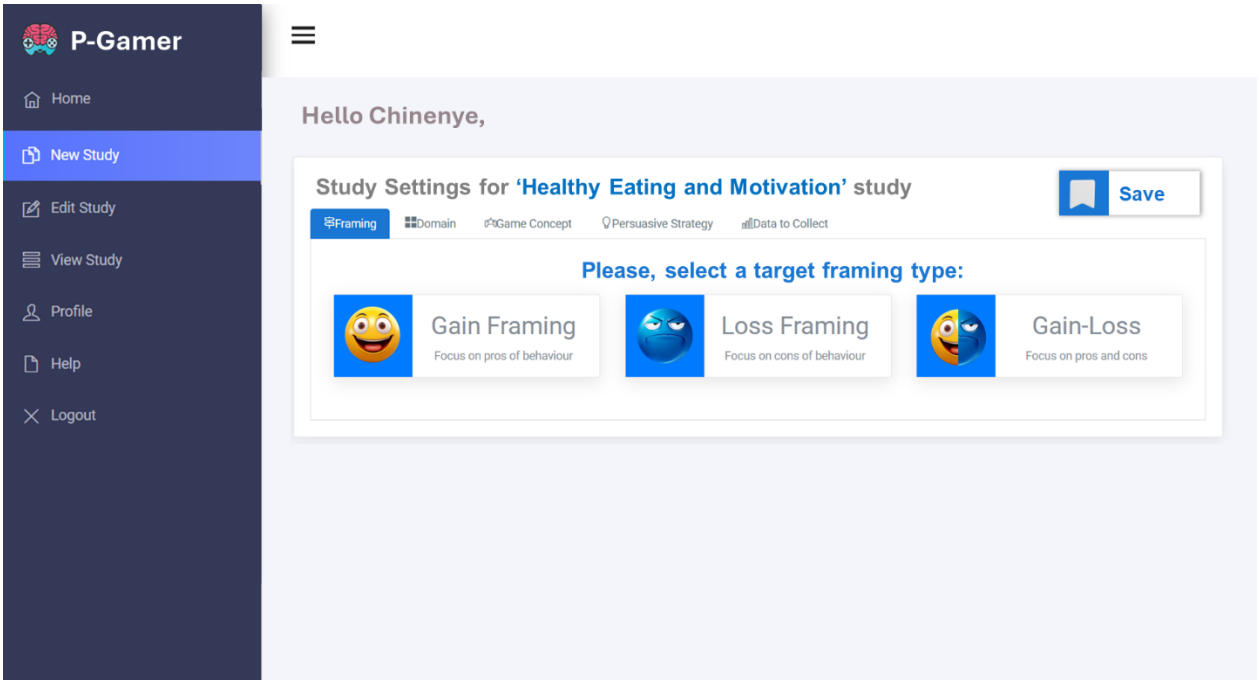
New Account Page



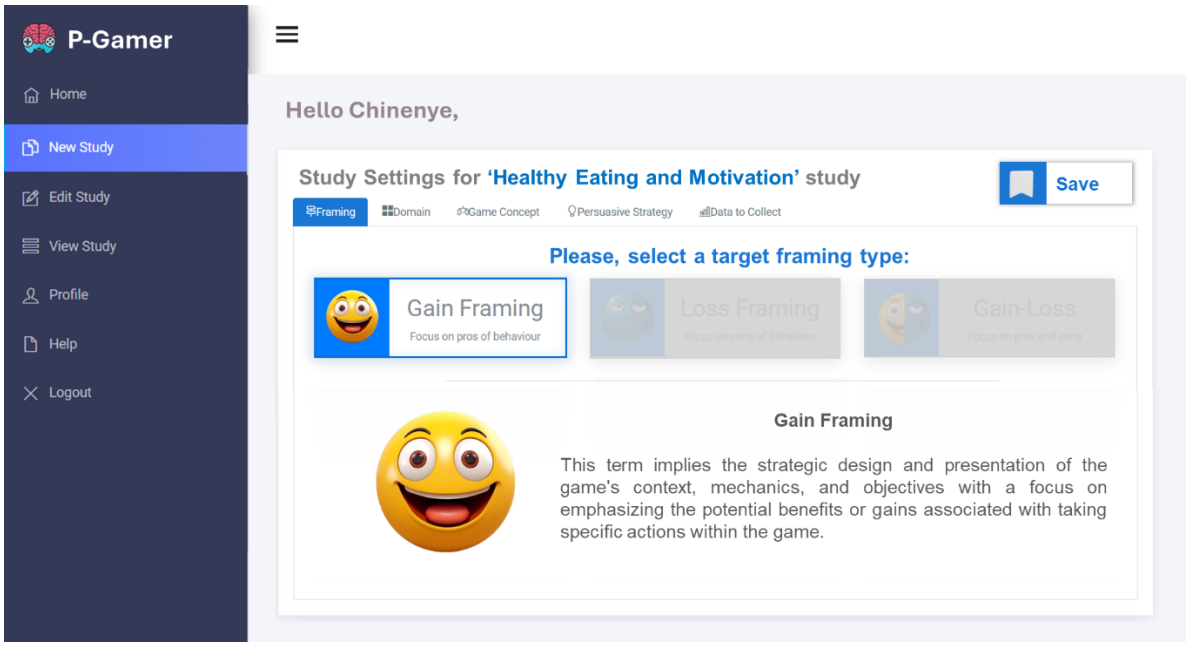
Home Page



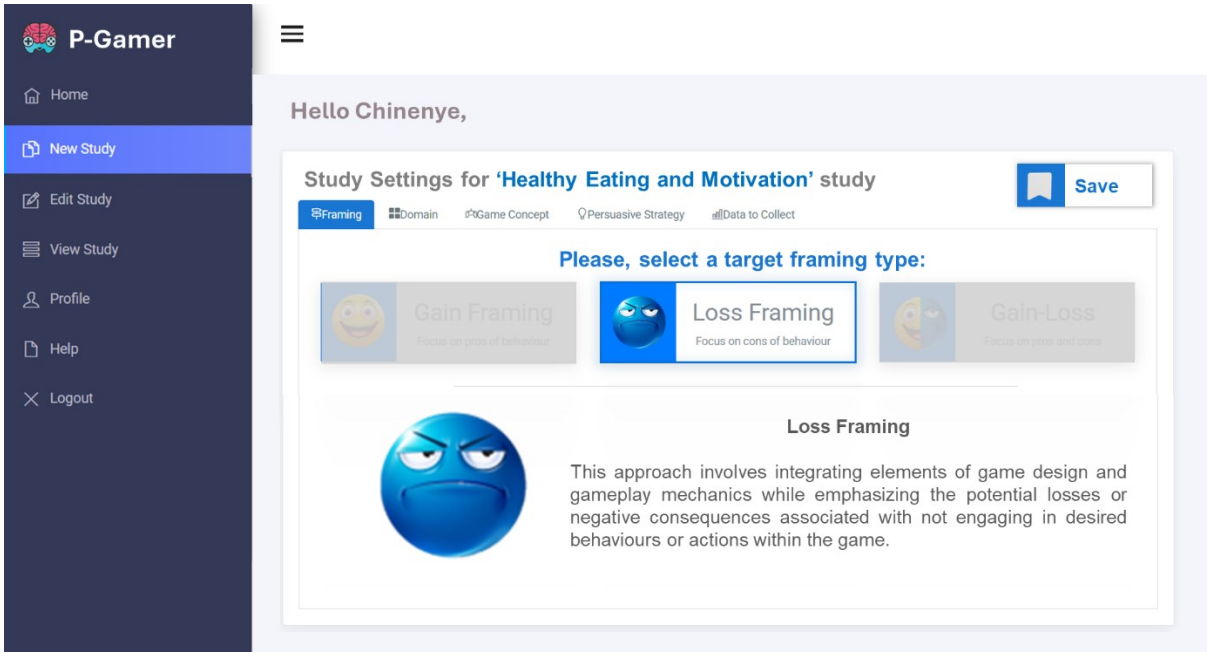
New Study Page



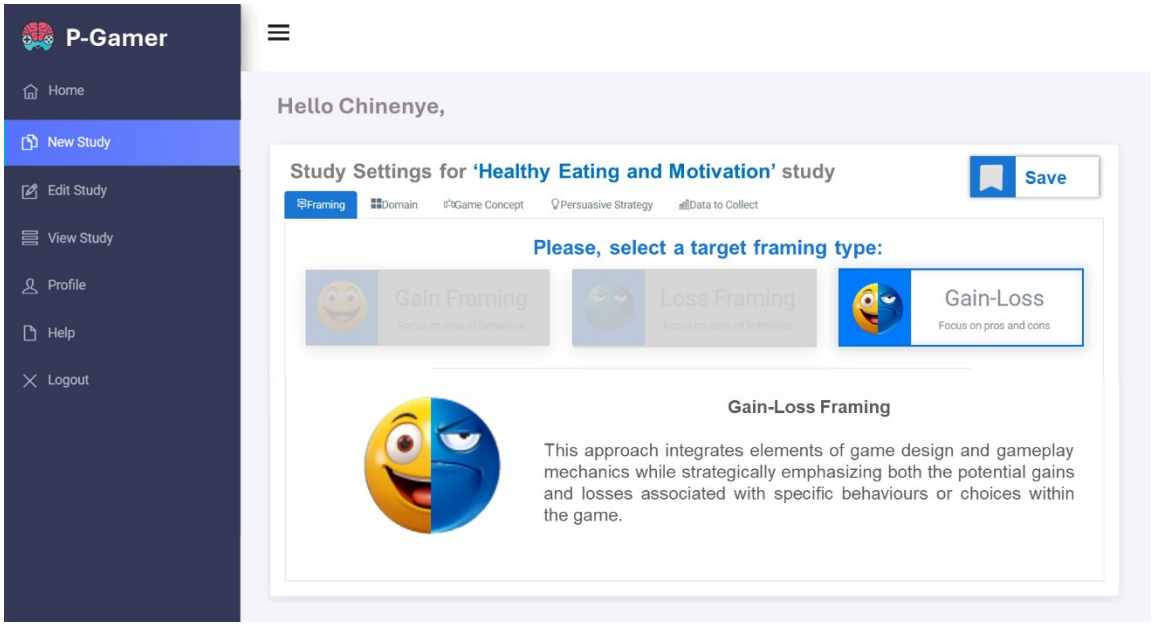
Framing Type page



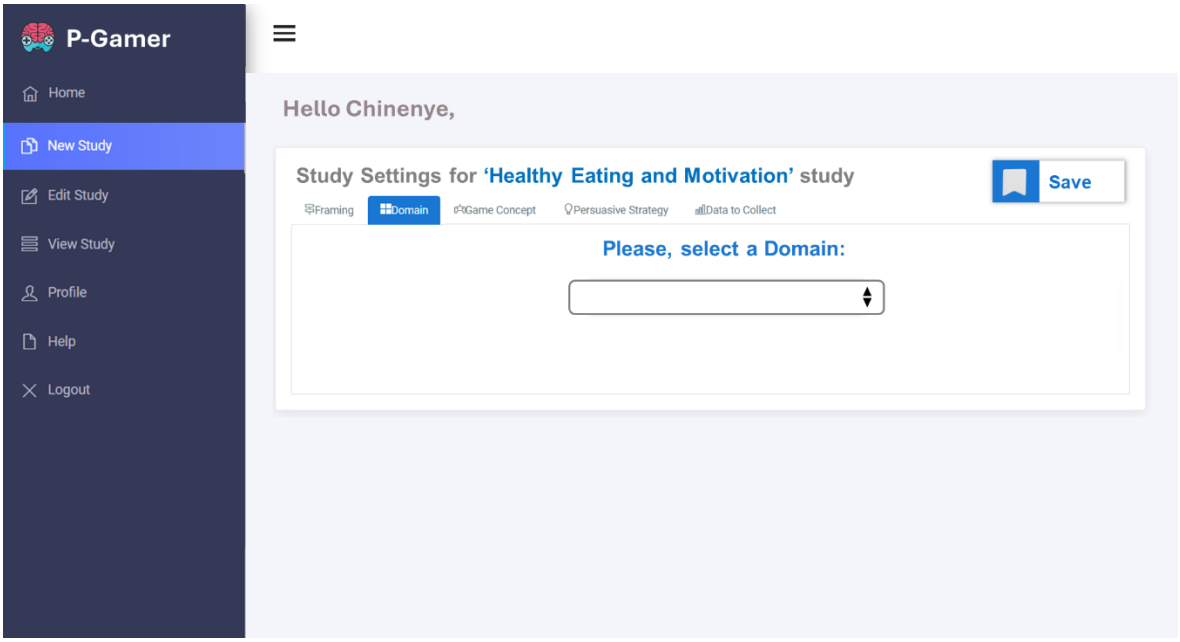
Framing Type page: Gain Framing



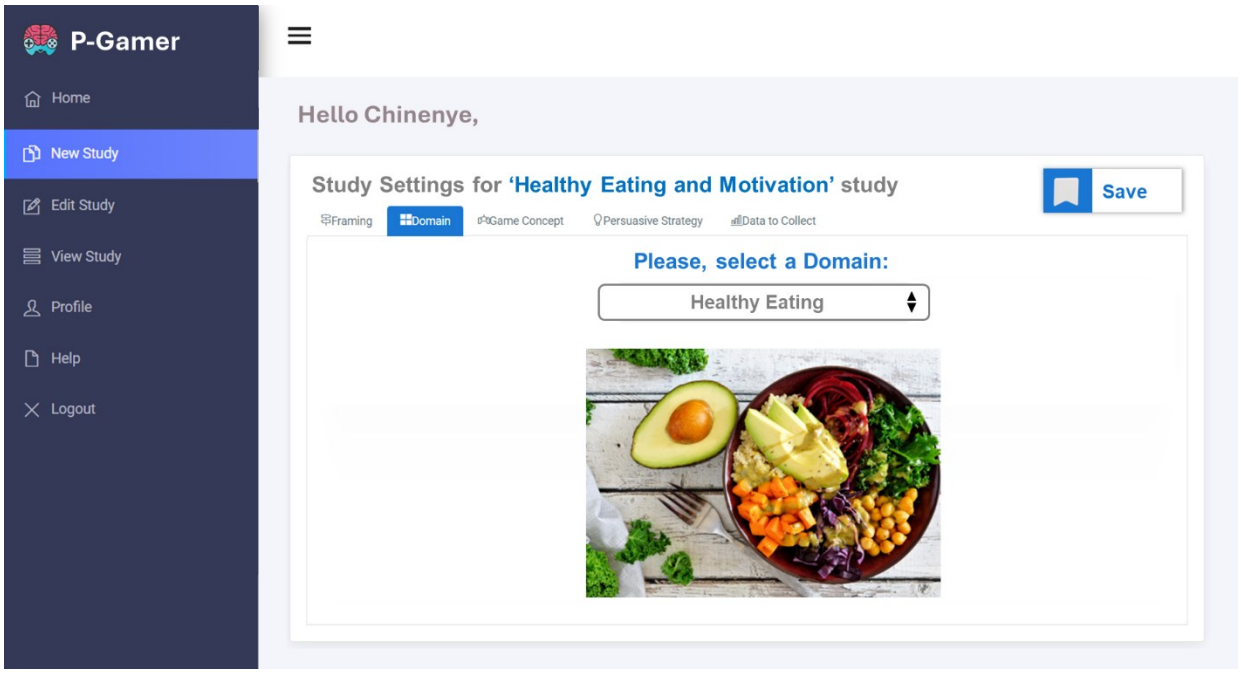
Framing Type page: Loss Framing



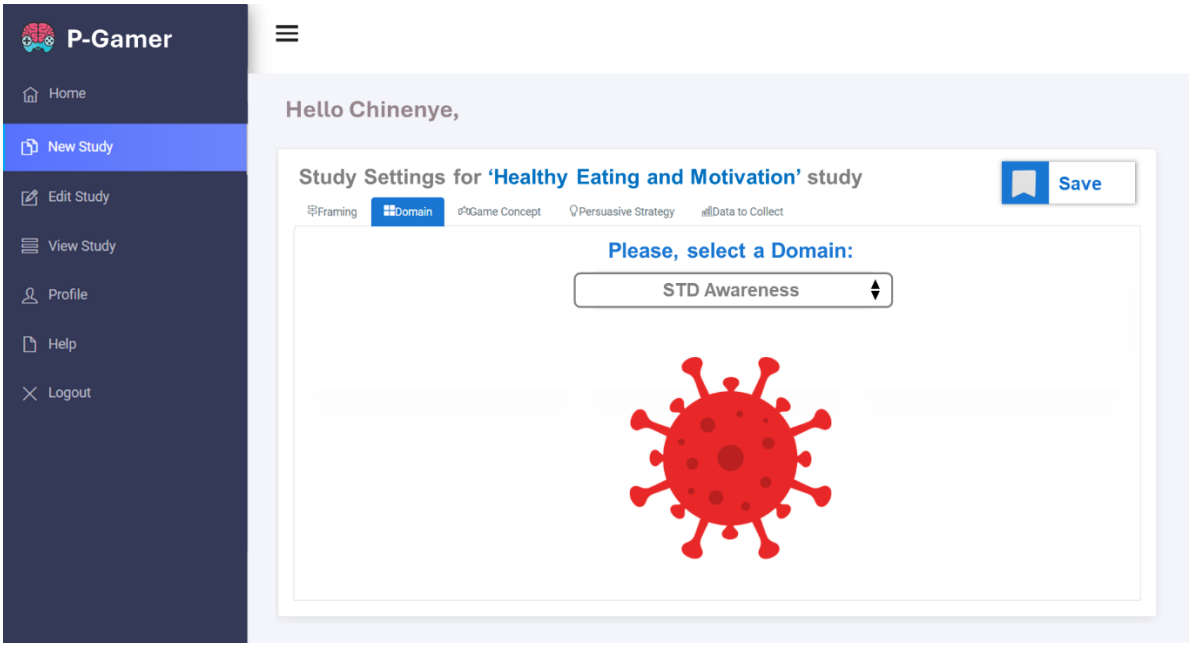
Framing Type page: Gain-Loss Framing



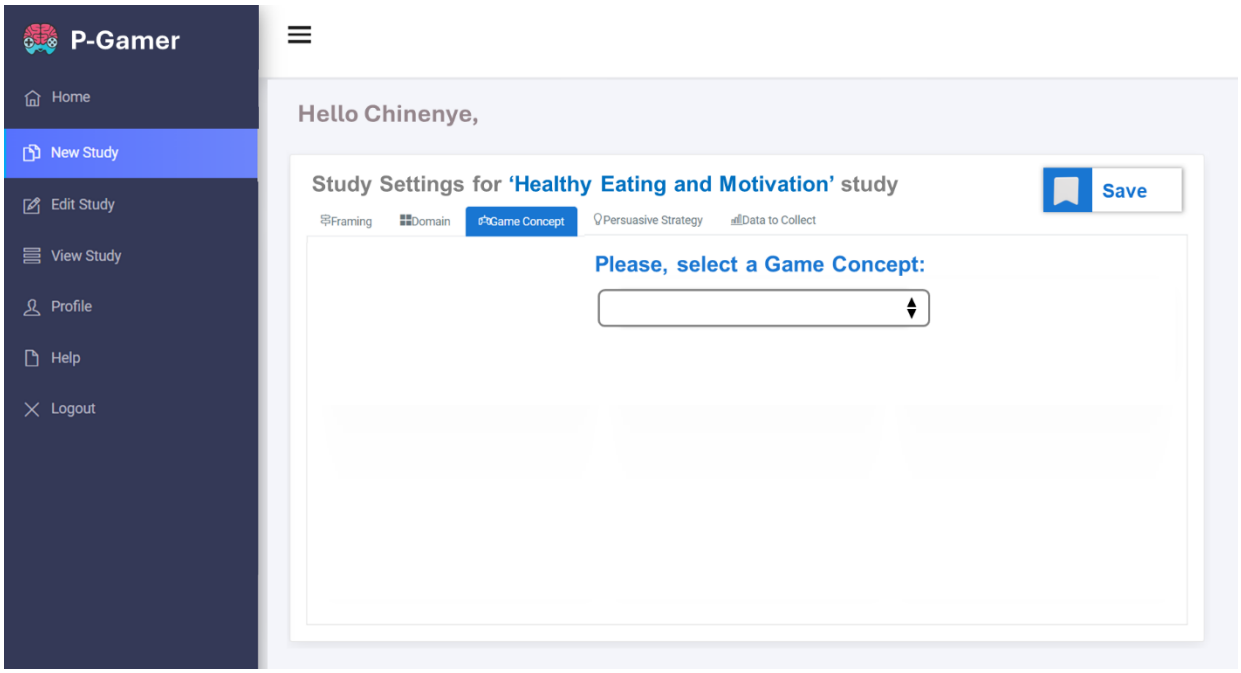
Domain Selection page



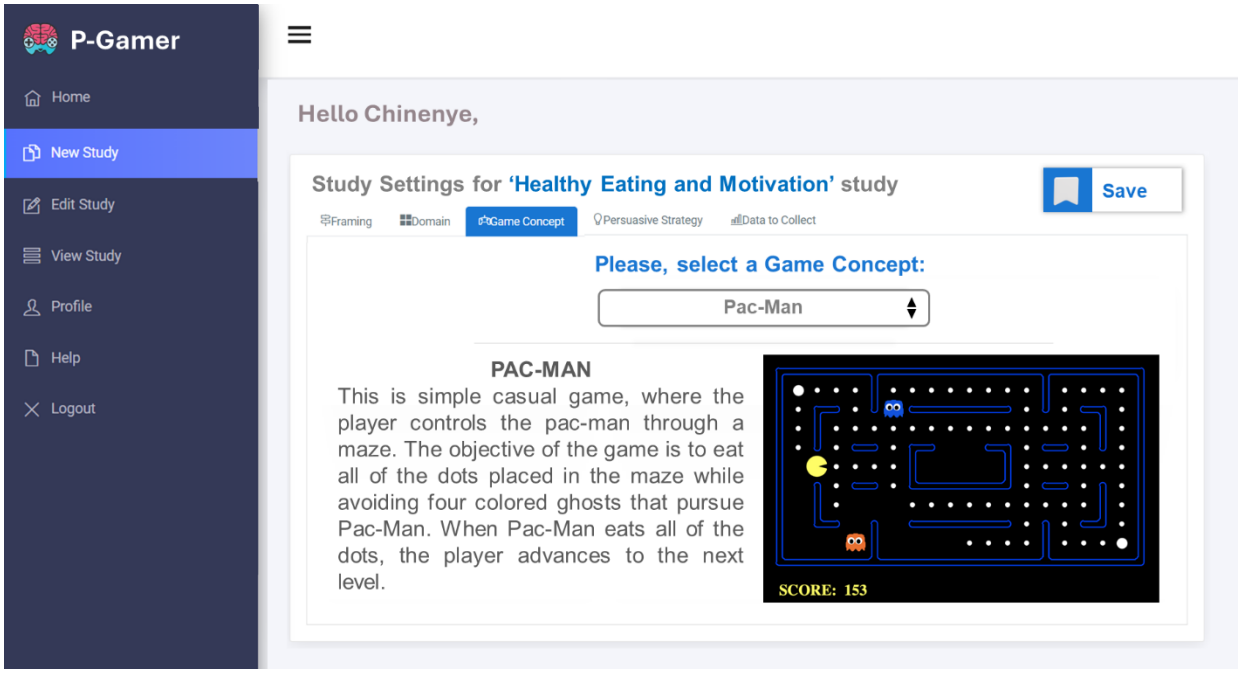
Domain page: Healthy Eating



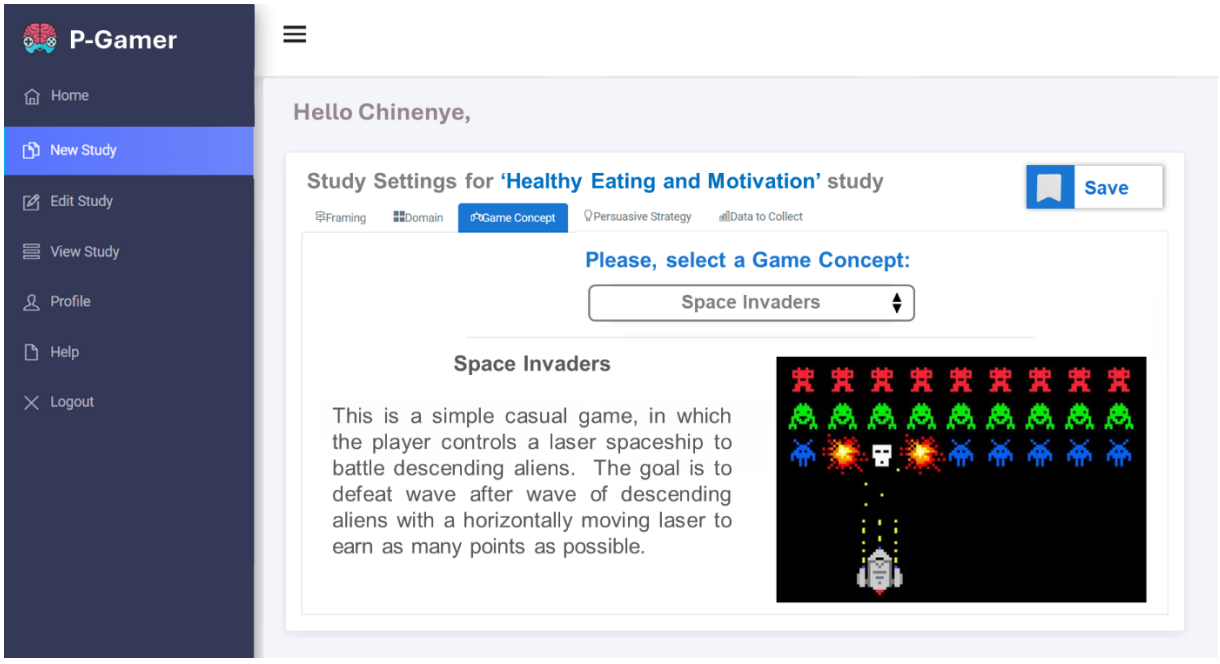
Domain page: STD Awareness



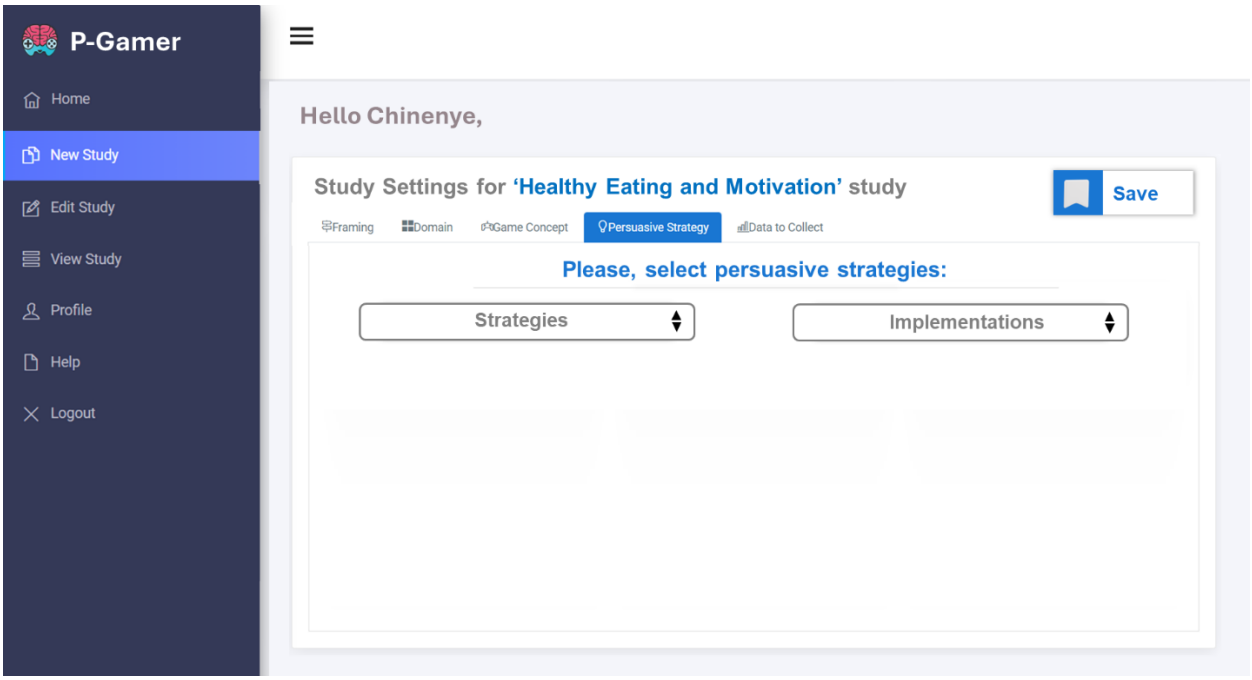
Game Concept Page



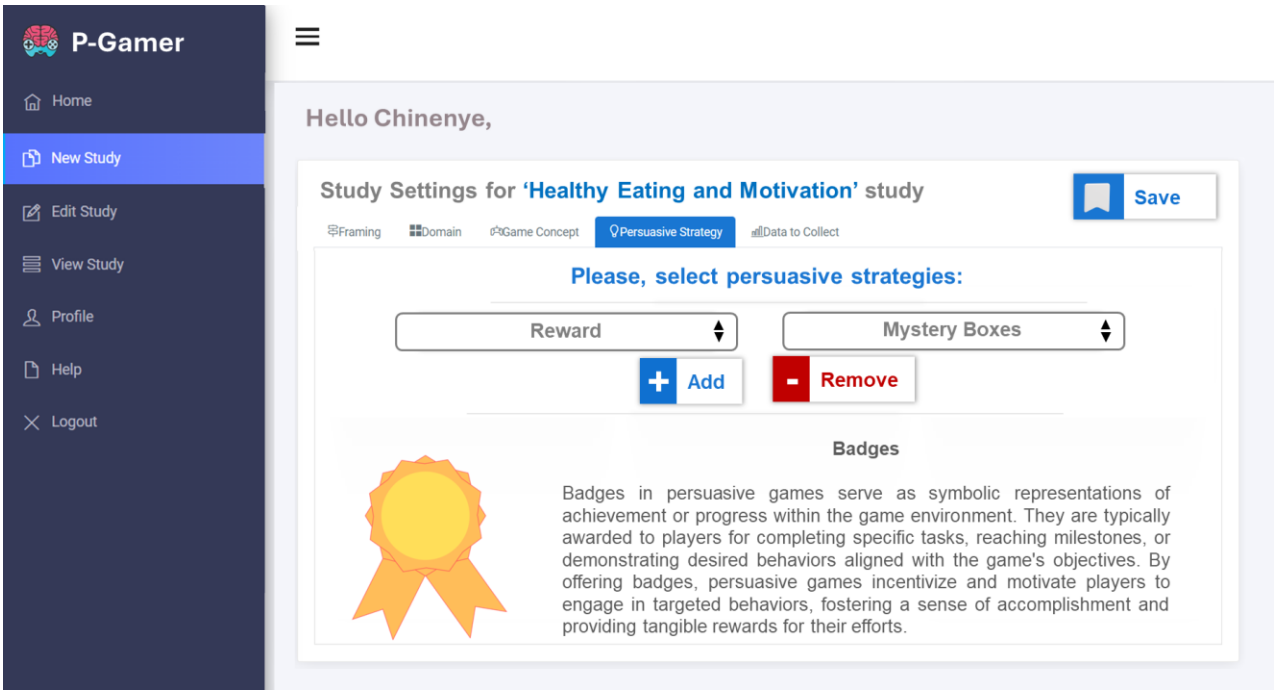
Game Concept Page: Pac-Man



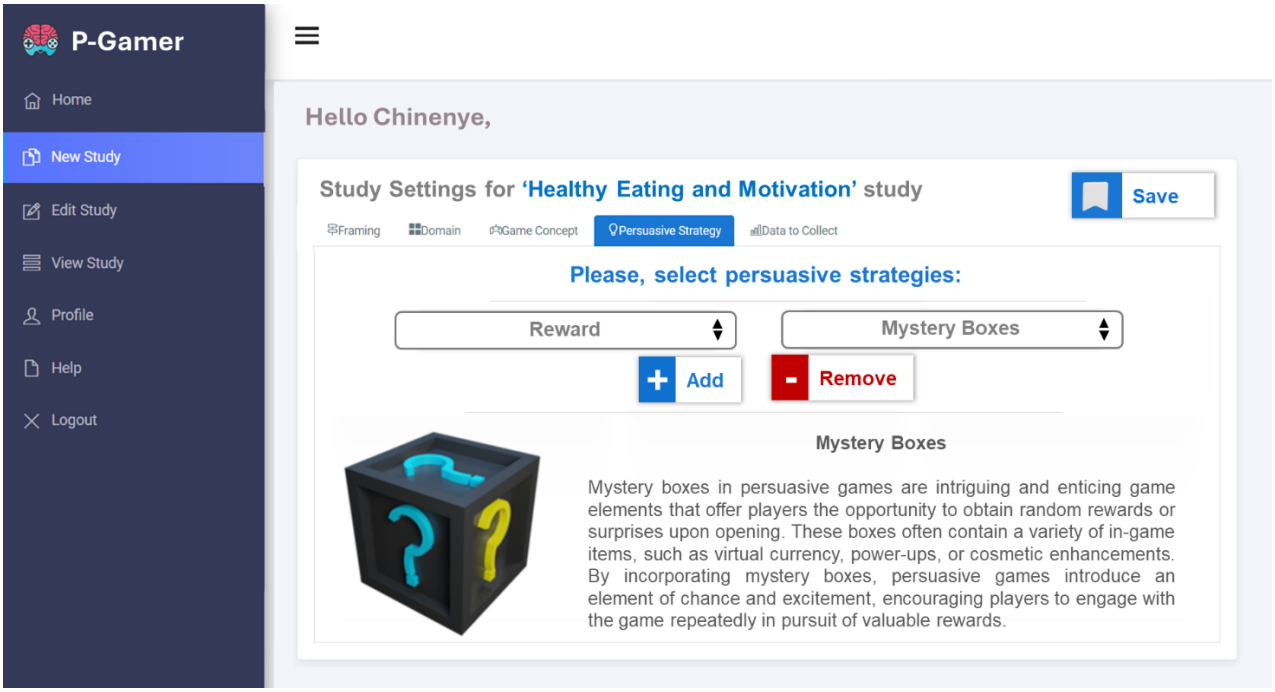
Game Concept Page: Space Invaders



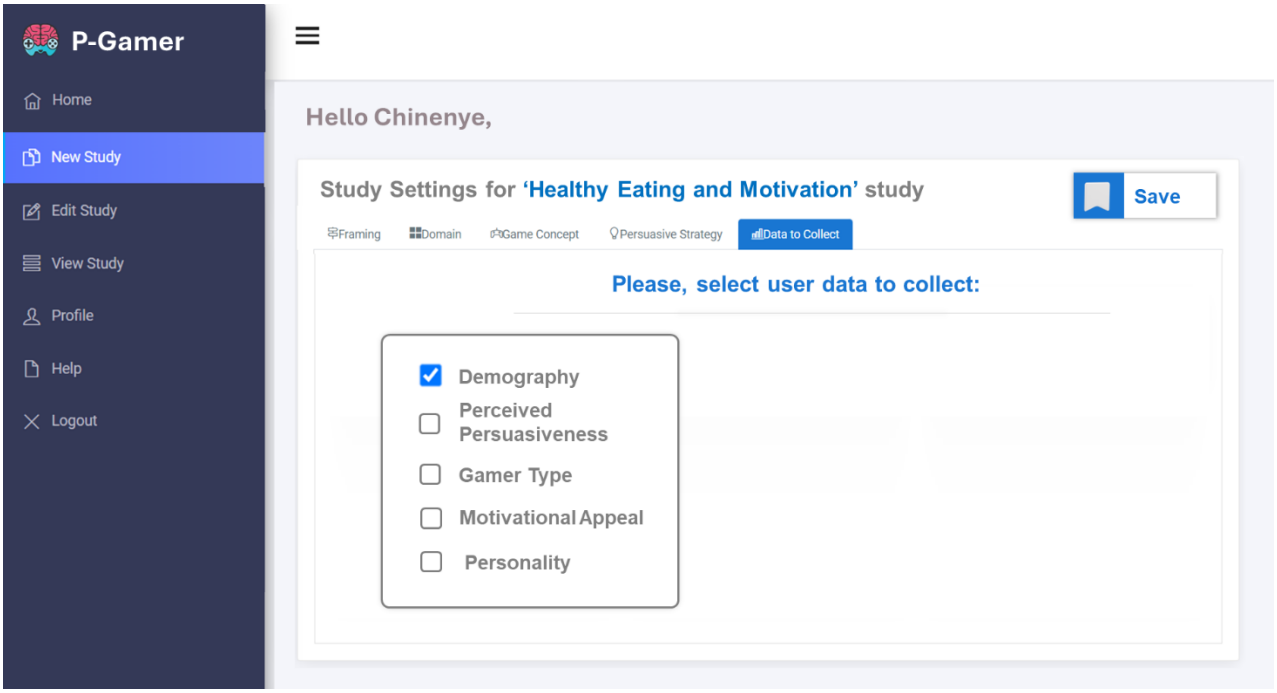
Persuasive Strategy Page



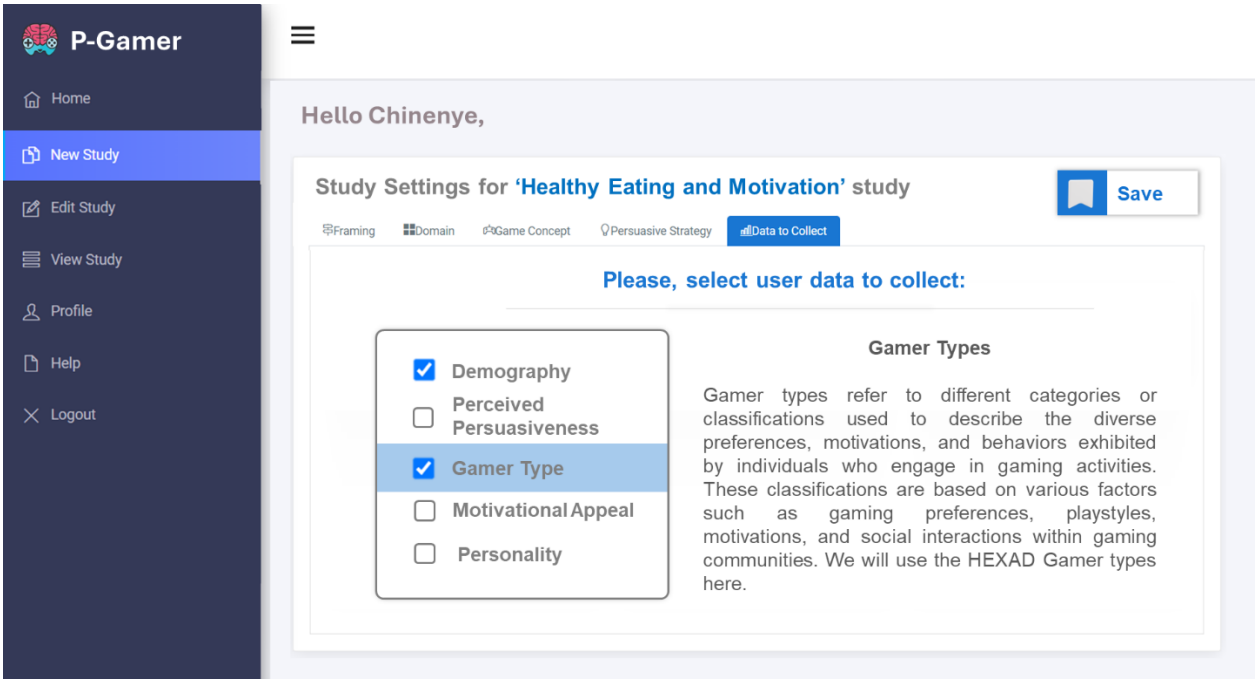
Persuasive Strategy Page: Reward (Badges)



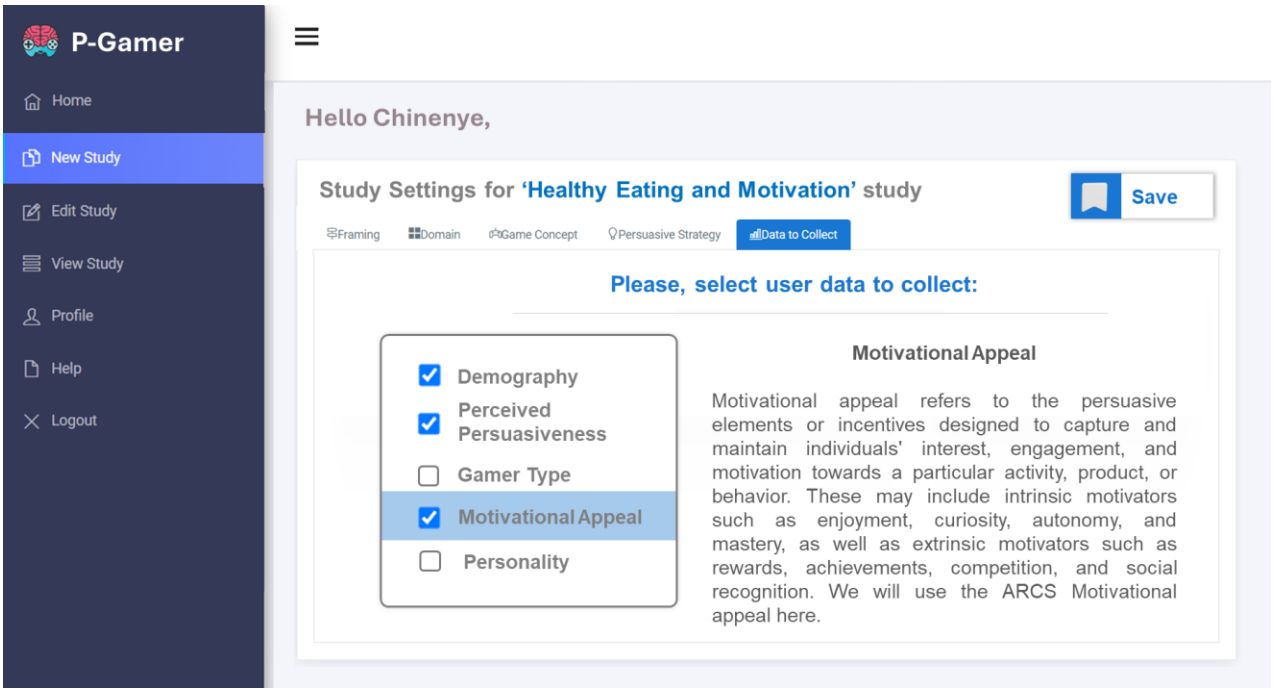
Persuasive Strategy Page: Reward (Mystery Boxes)



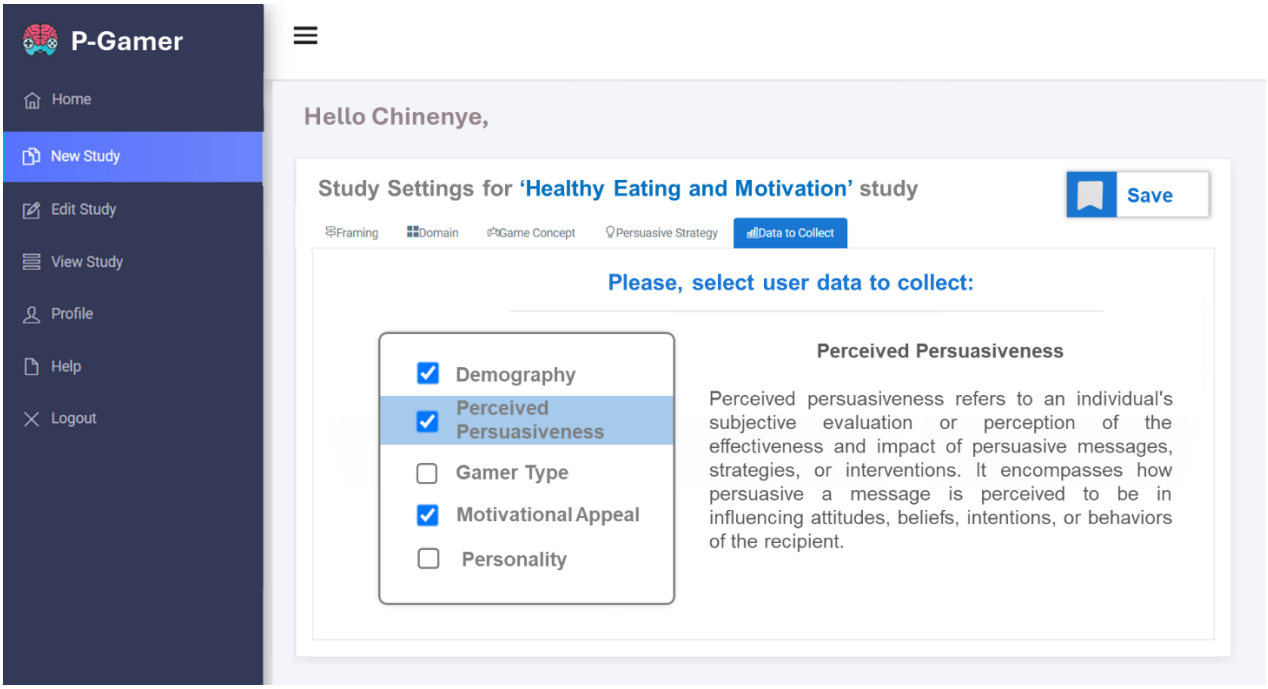
User Data Page



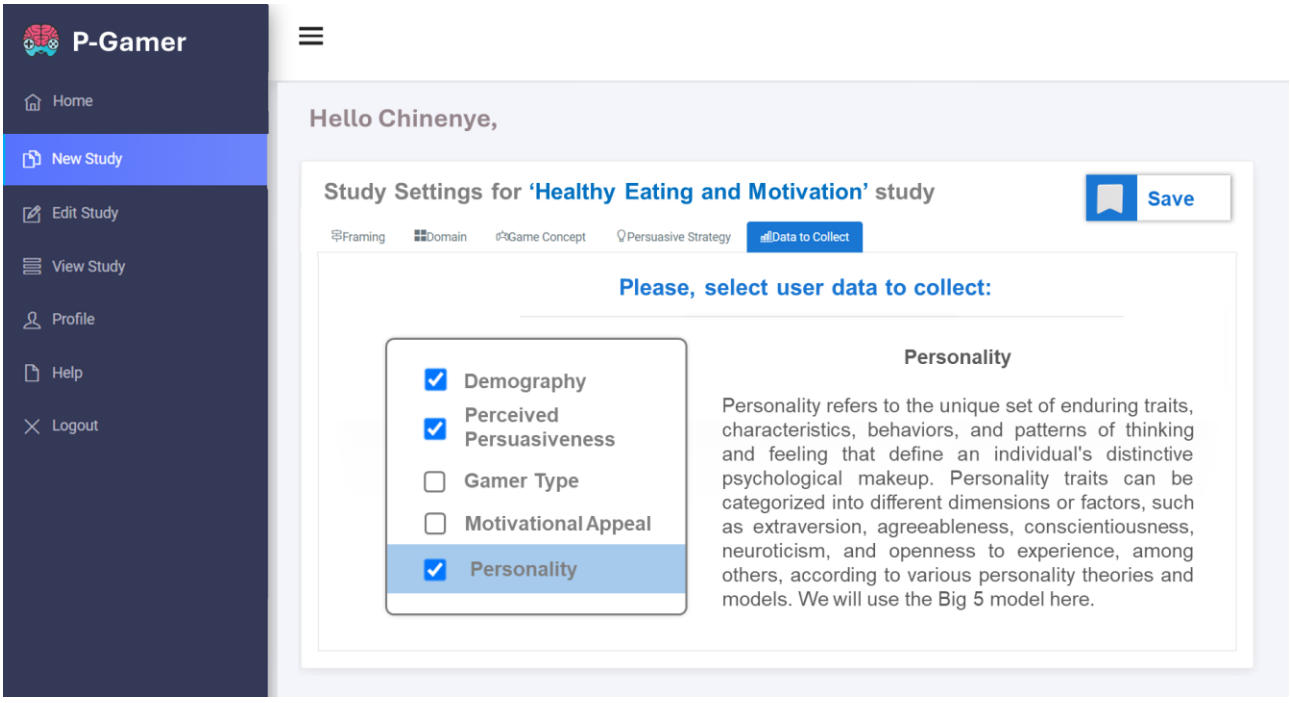
User Data Page: Gamer Types



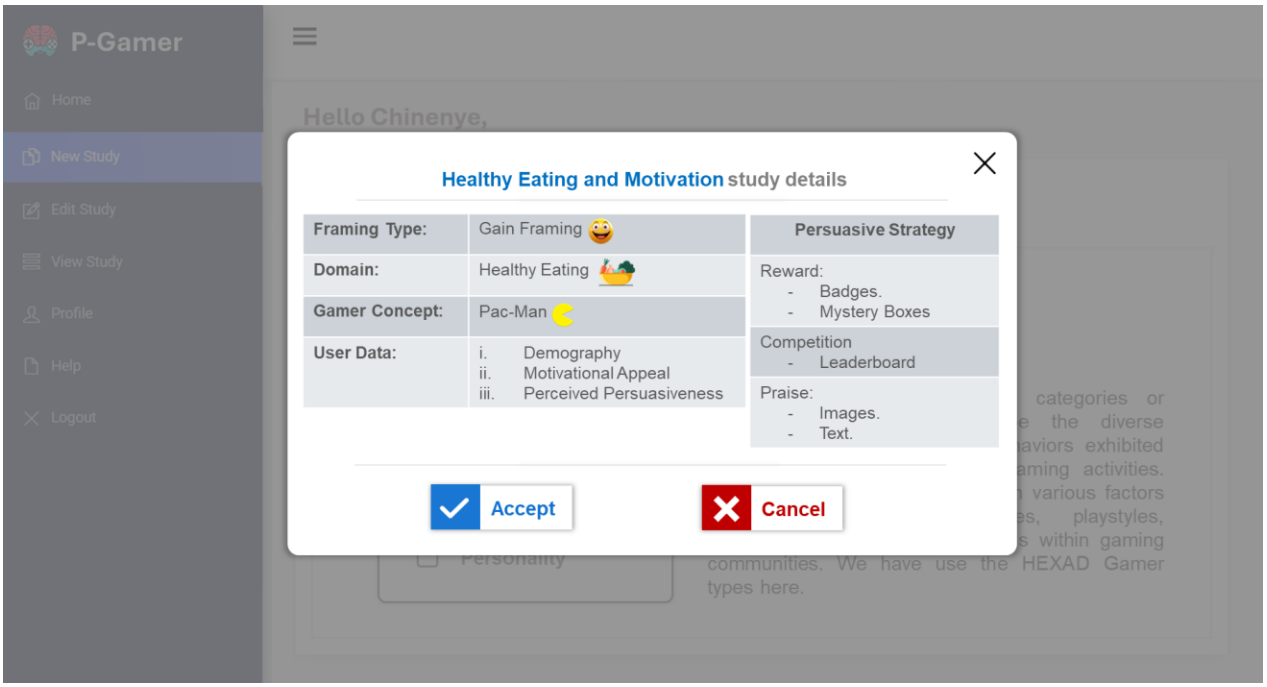
User Data Page: Motivational Appeal



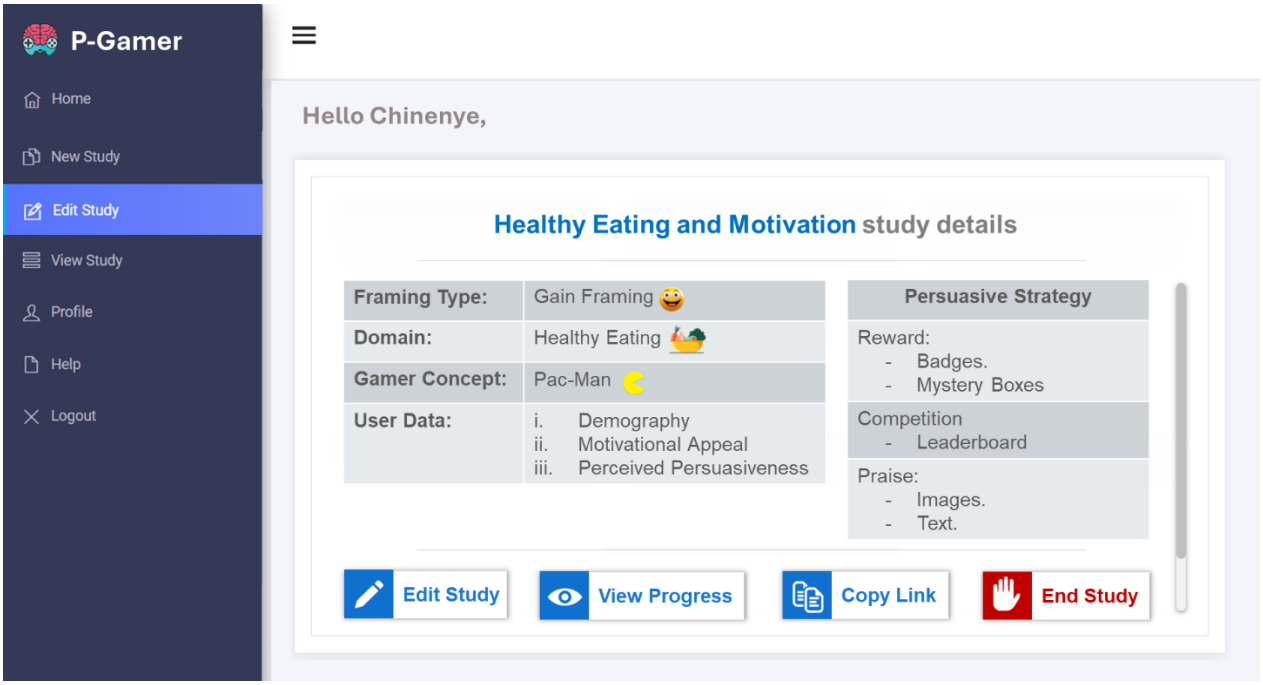
User Data Page: Perceived Persuasiveness



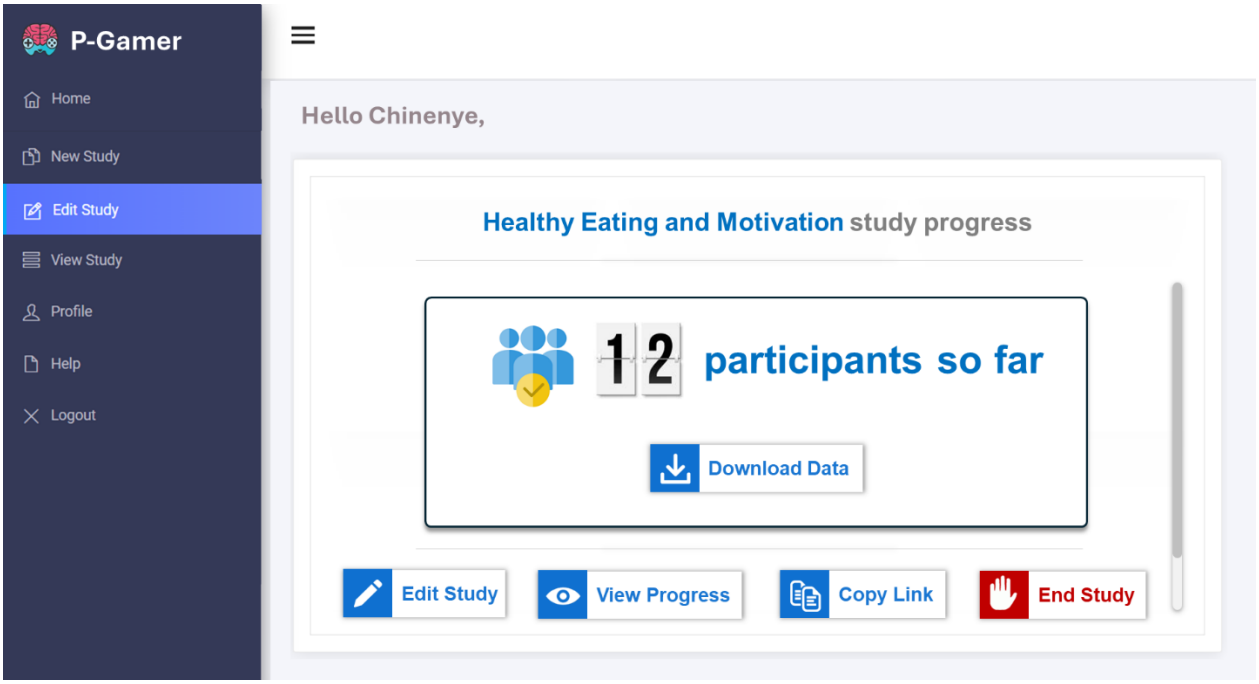
User Data Page: Personality



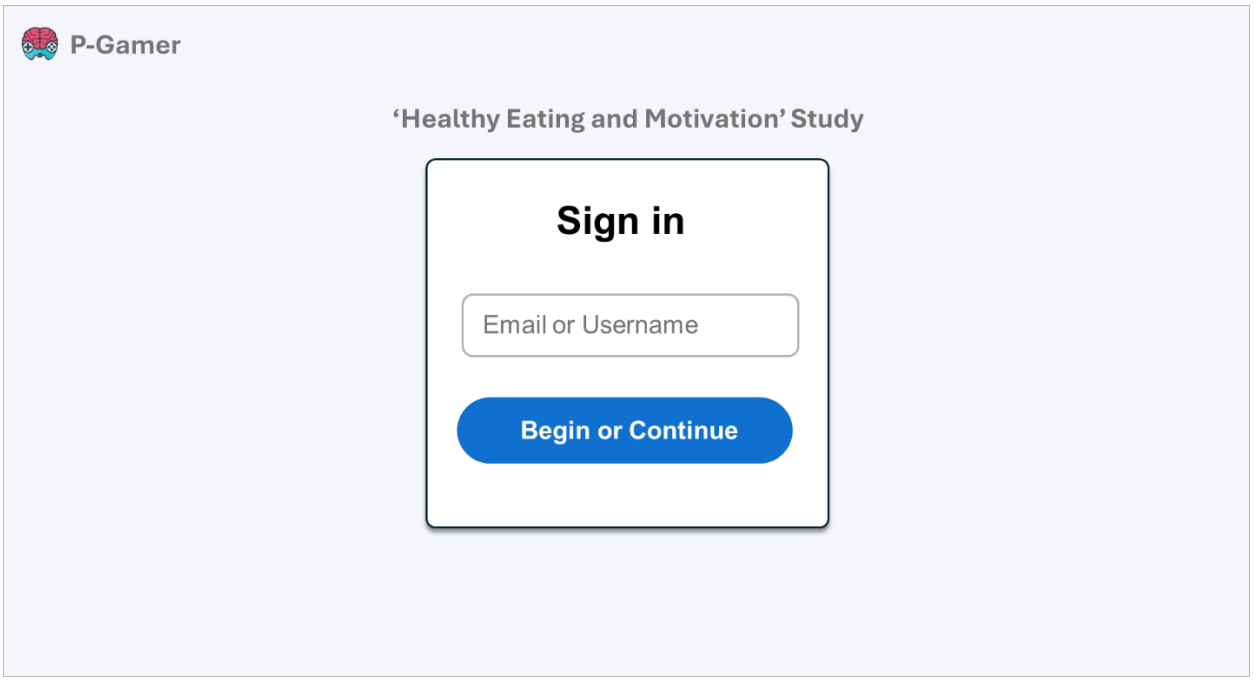
Save Study page.



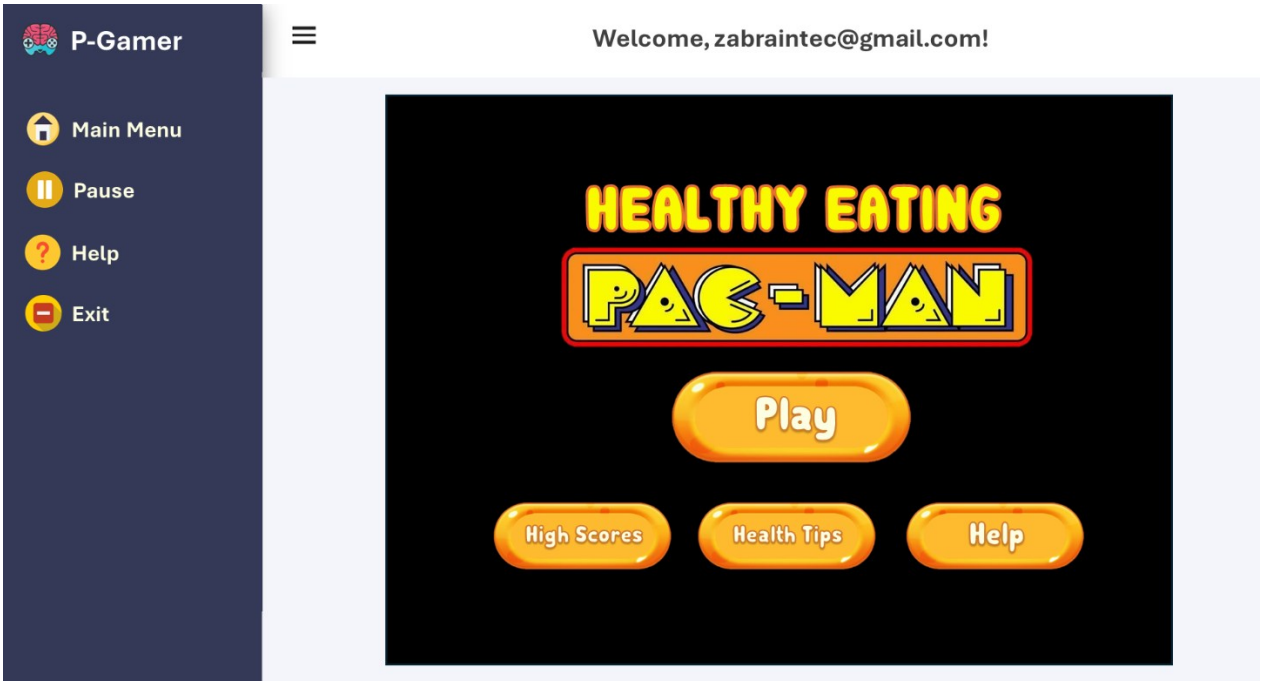
View/Edit Study page.



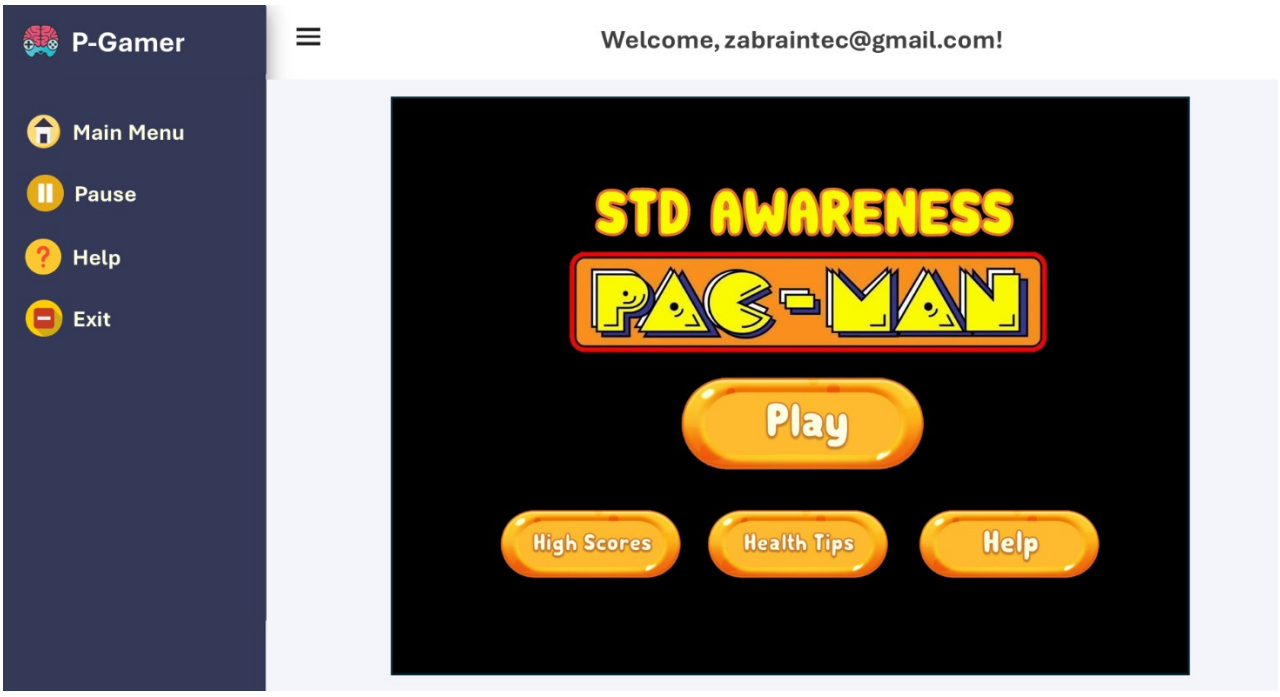
View Study Progress Study page.



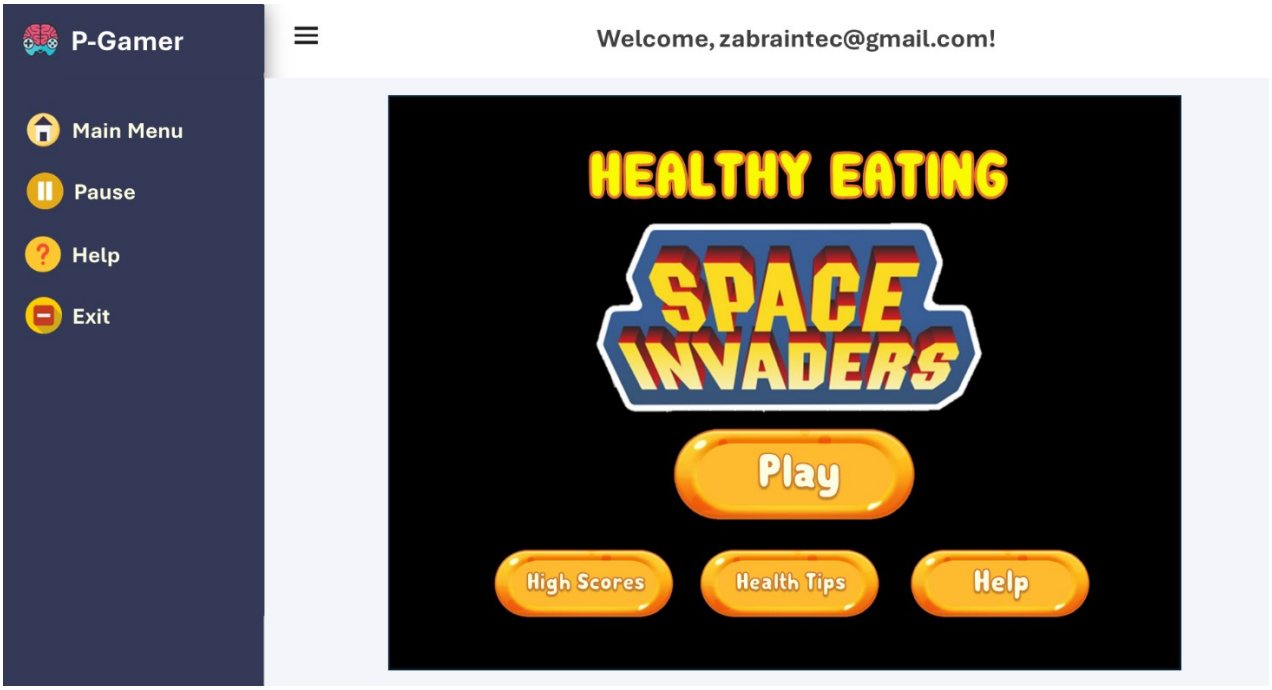
Participant Signin



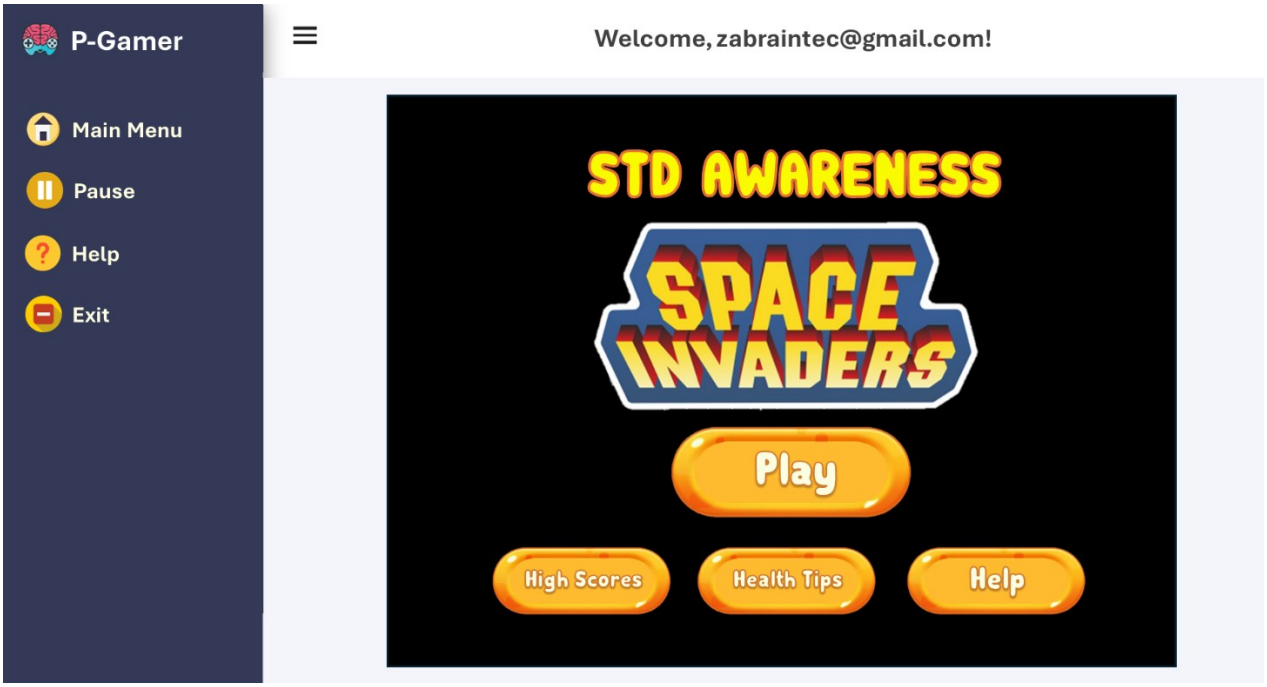
Healthy Eating Pac-Man Main Menu



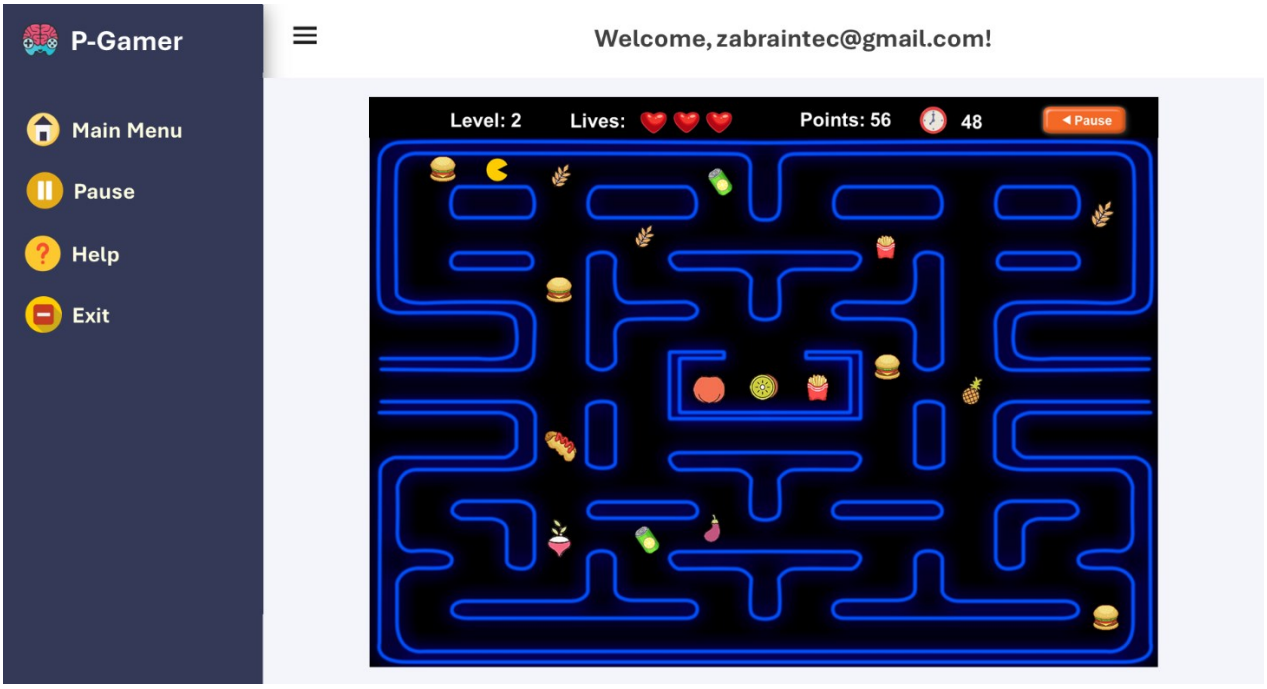
STD Awareness Pac-Man Main Menu



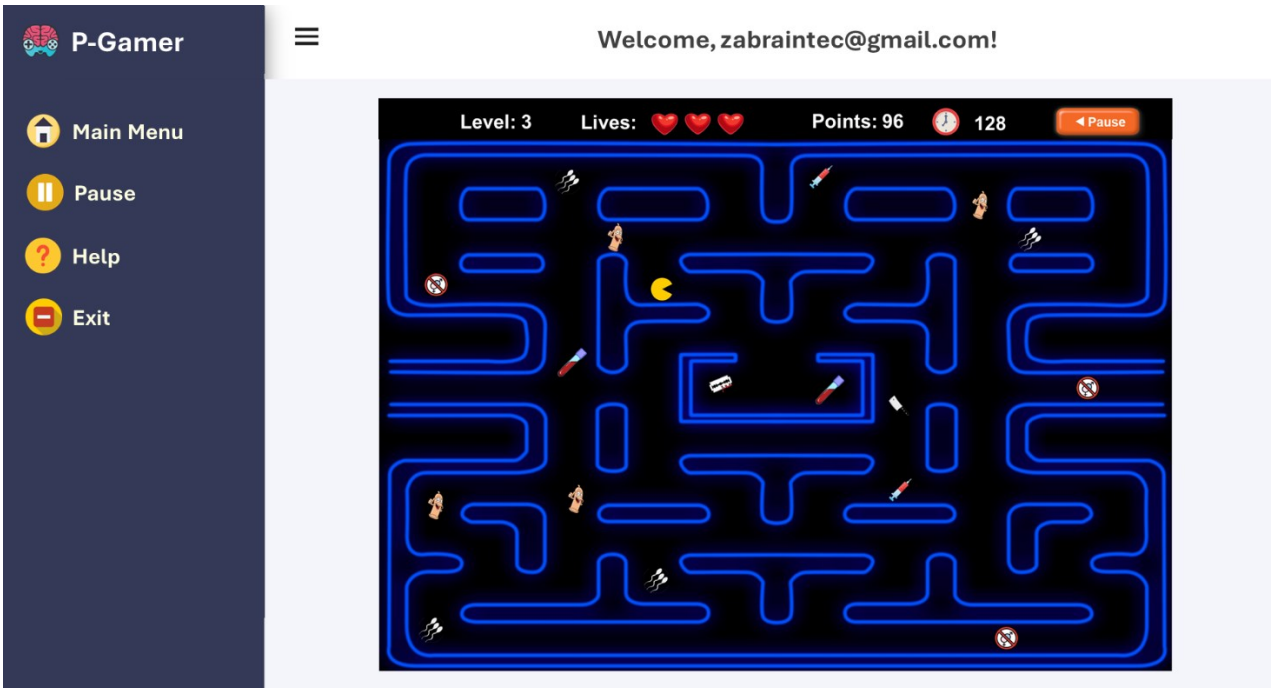
Healthy Eating Space Invaders Main Menu



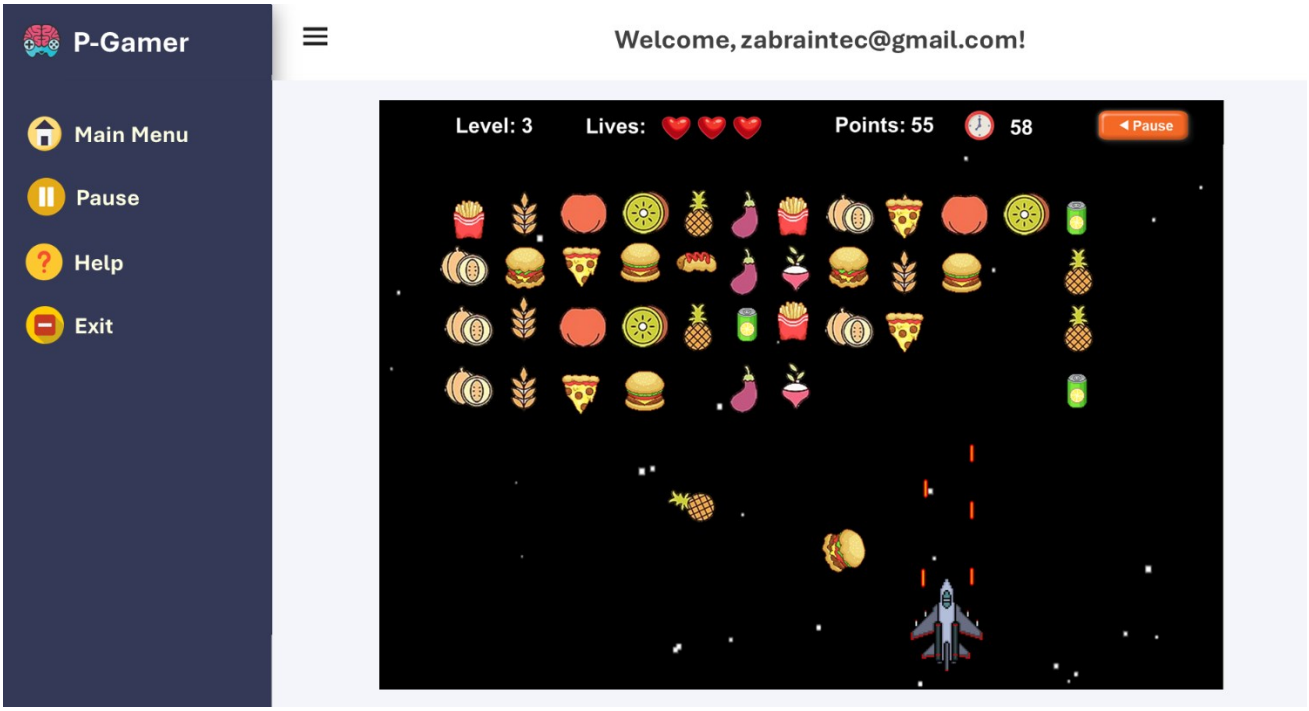
STD Awareness Space Invaders Main Menu



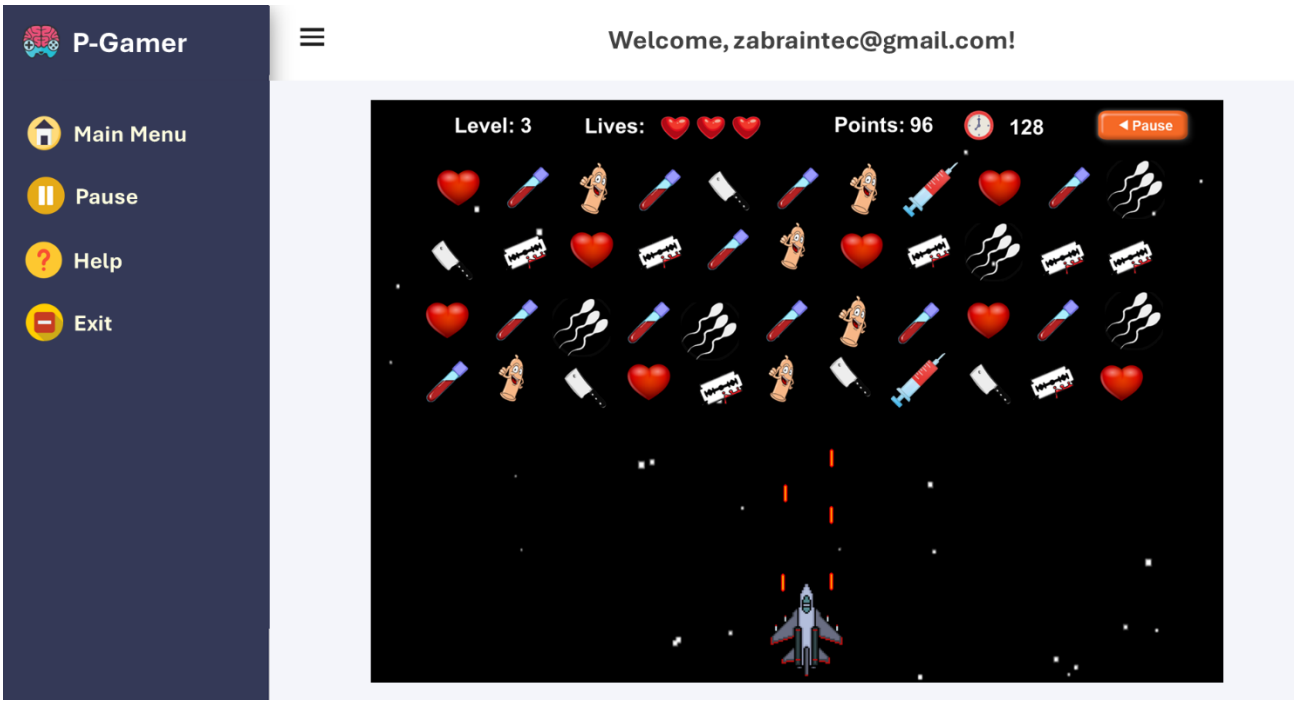
Healthy Eating Pac-Man Gameplay



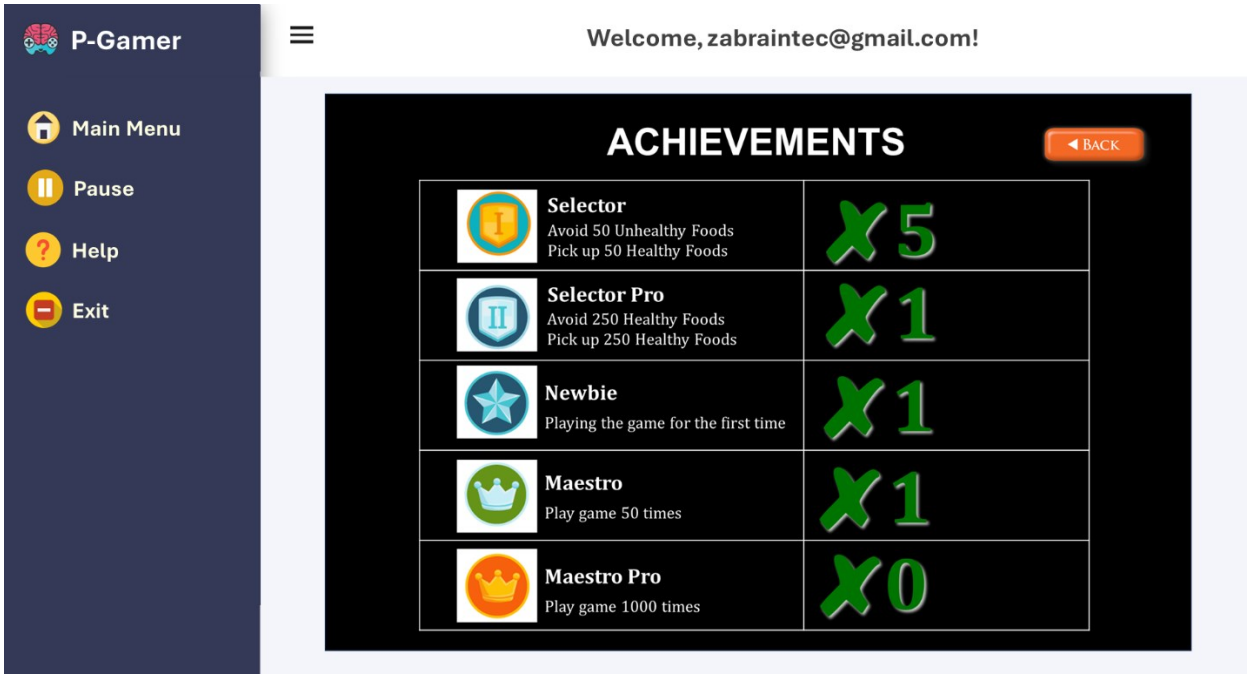
STD Awareness Pac-Man Gameplay



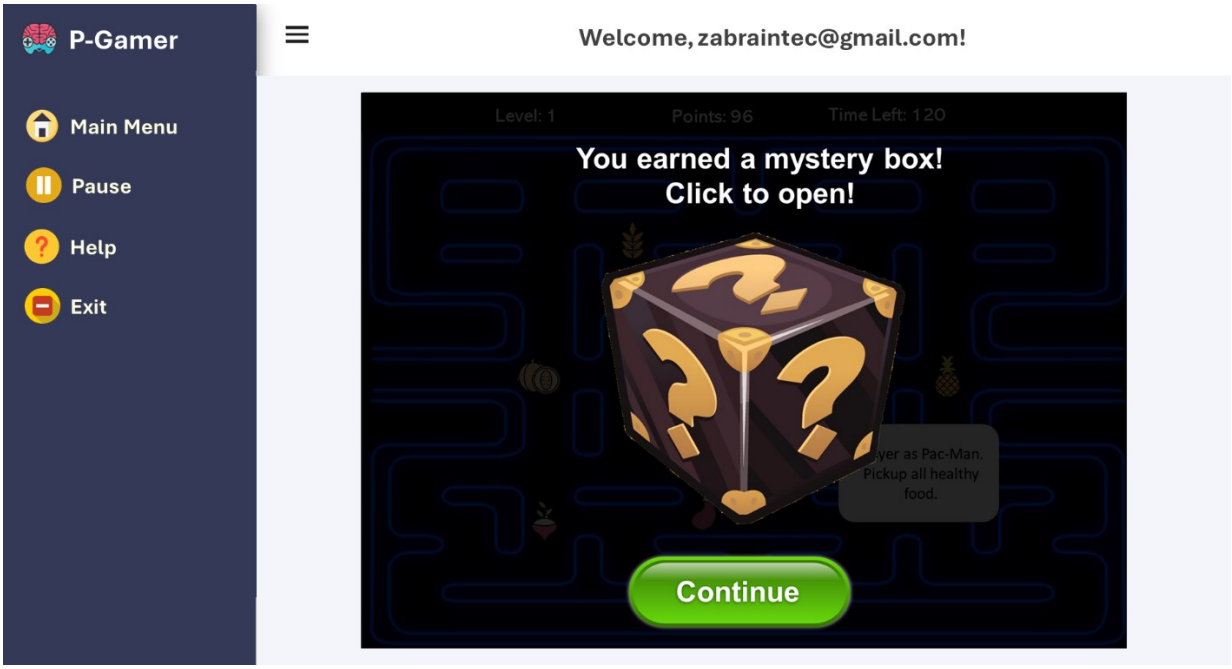
Healthy Eating Space Invaders Gameplay



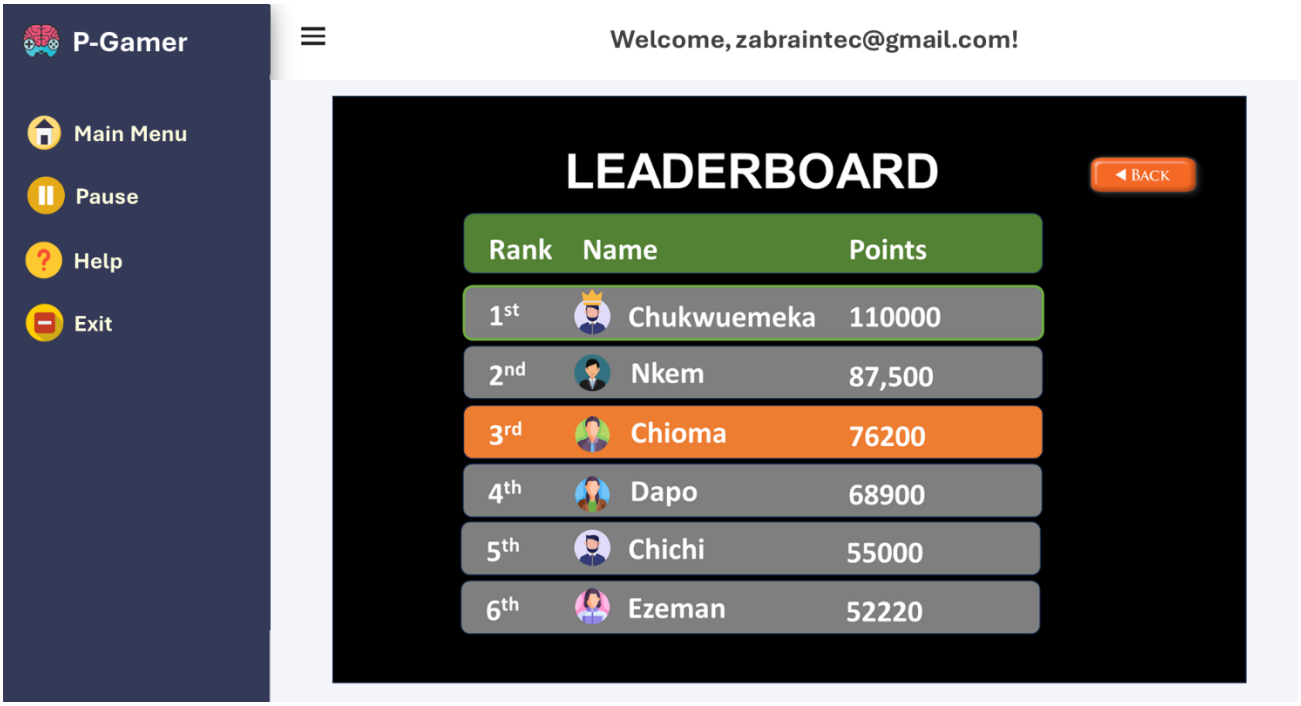
STD Awareness Space Invaders Gameplay



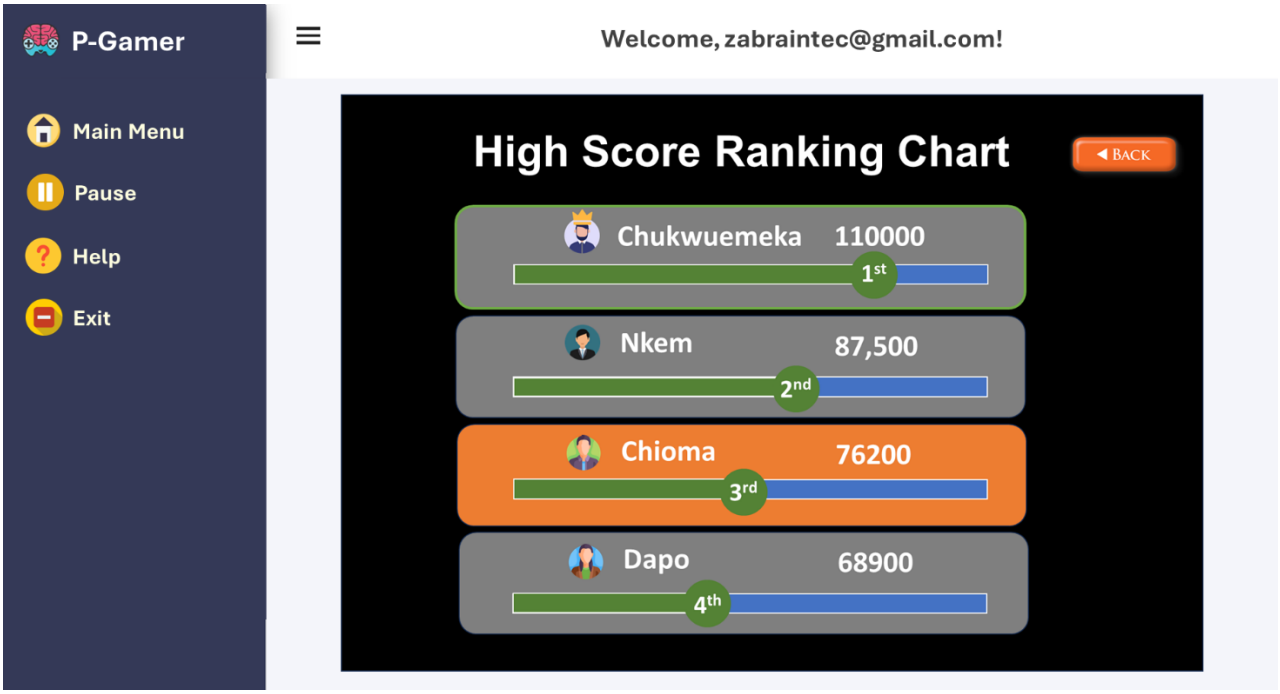
Reward Strategy 1



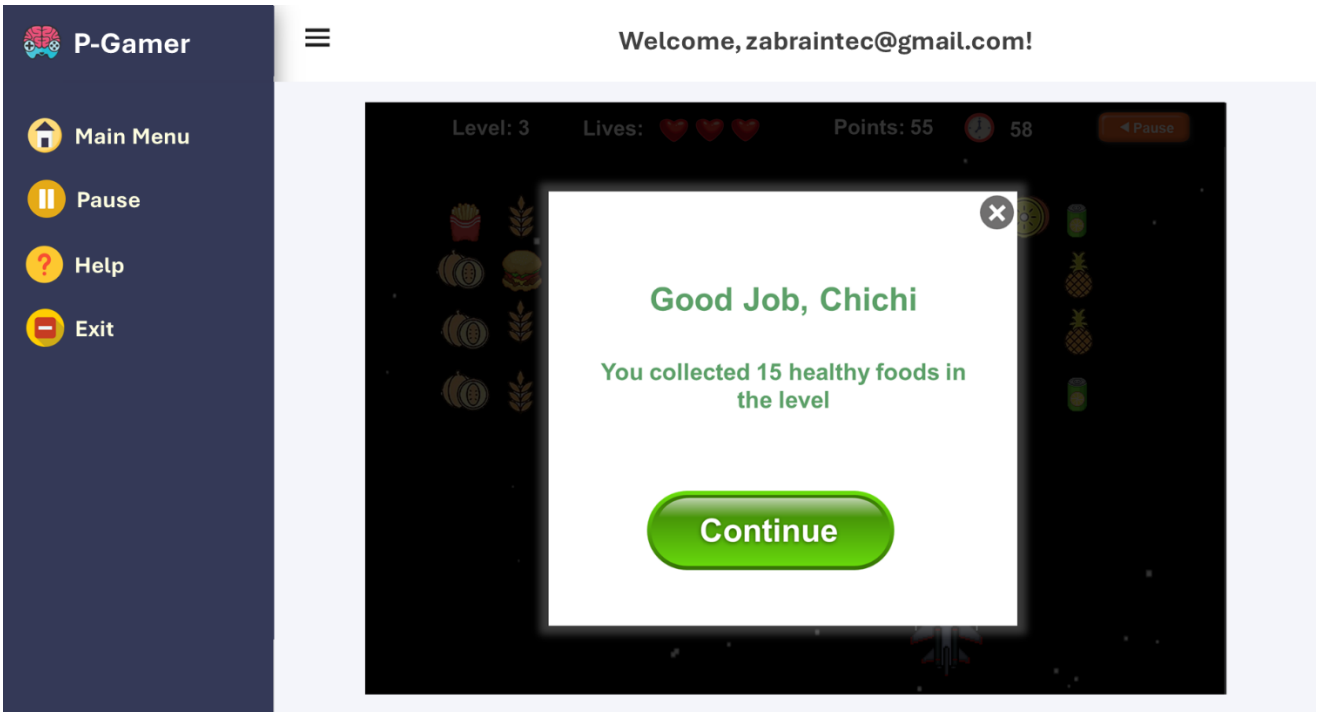
Reward Strategy 2



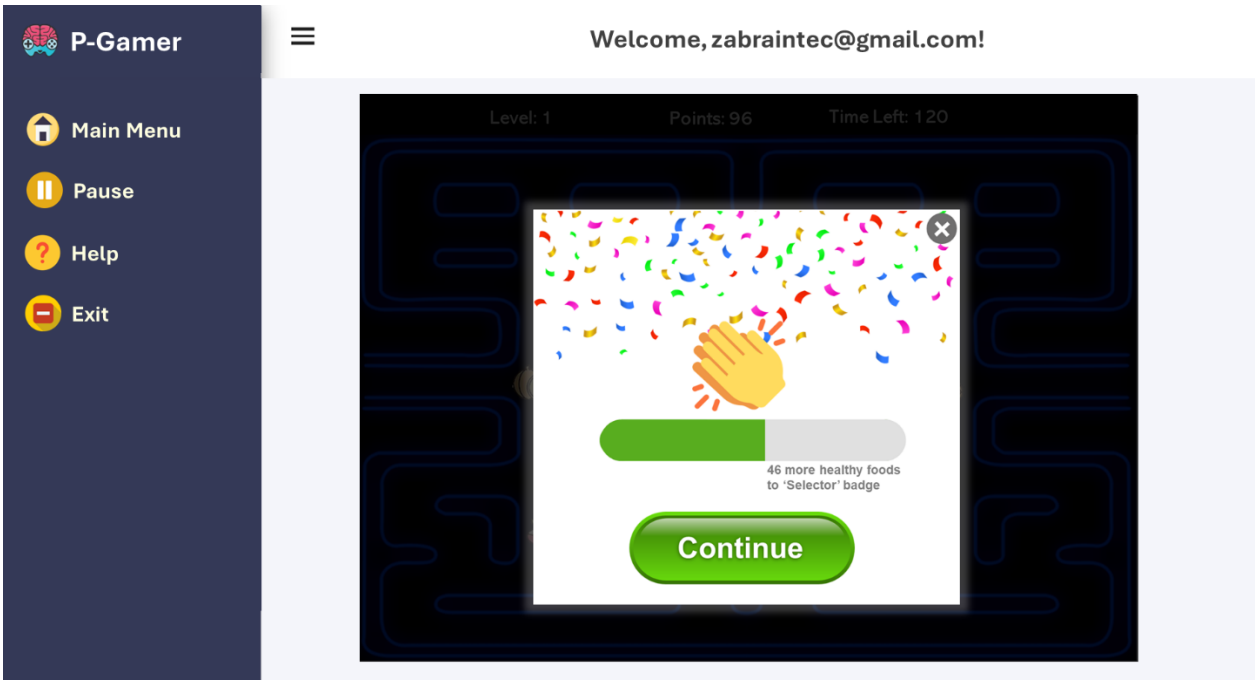
Competition Strategy 1



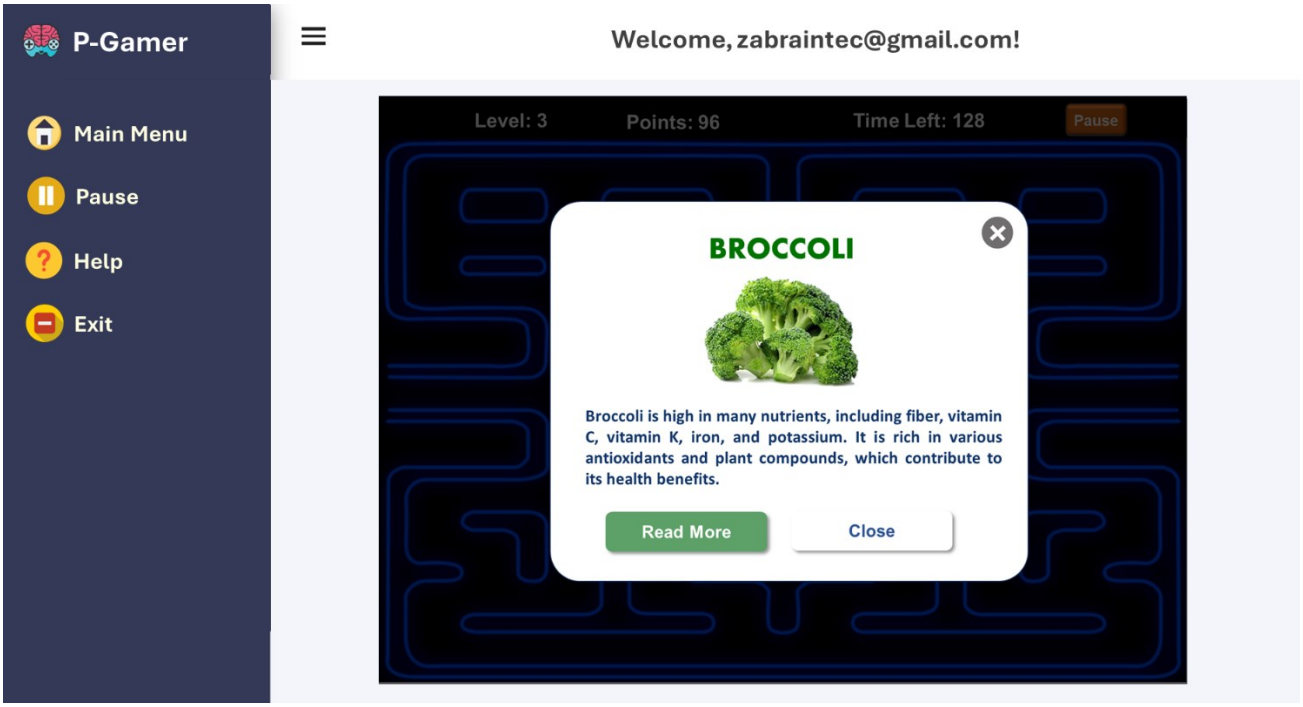
Competition Strategy 2



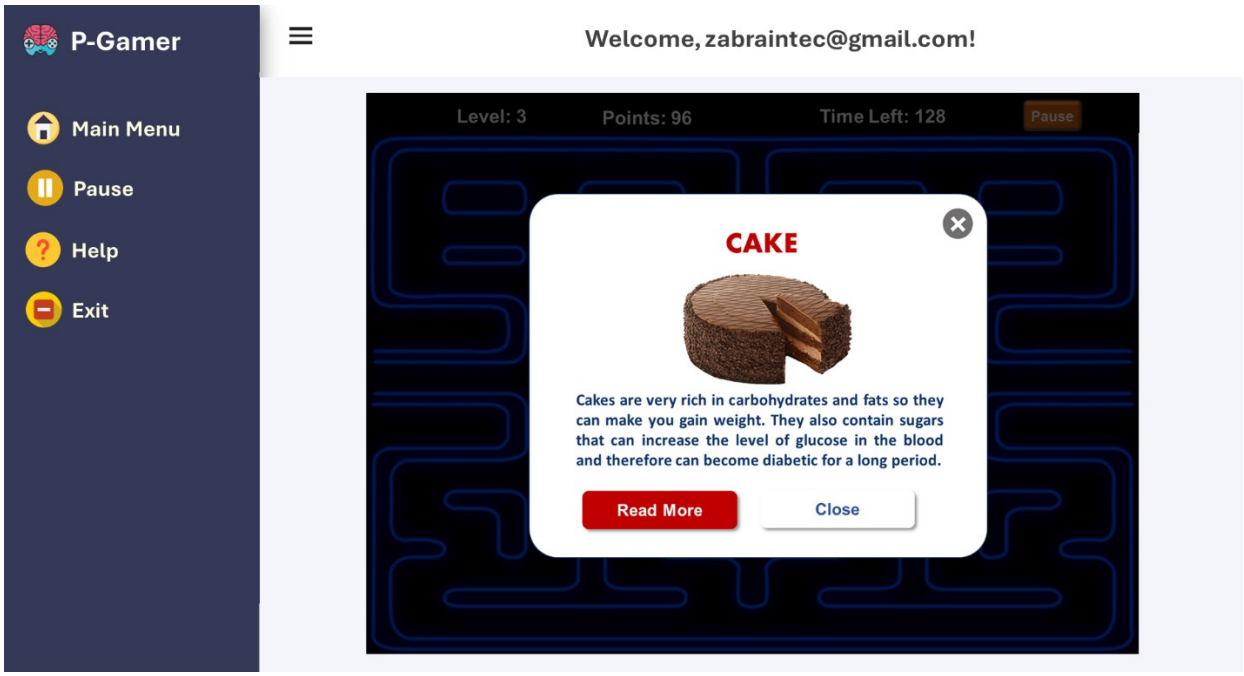
Praise Strategy 1



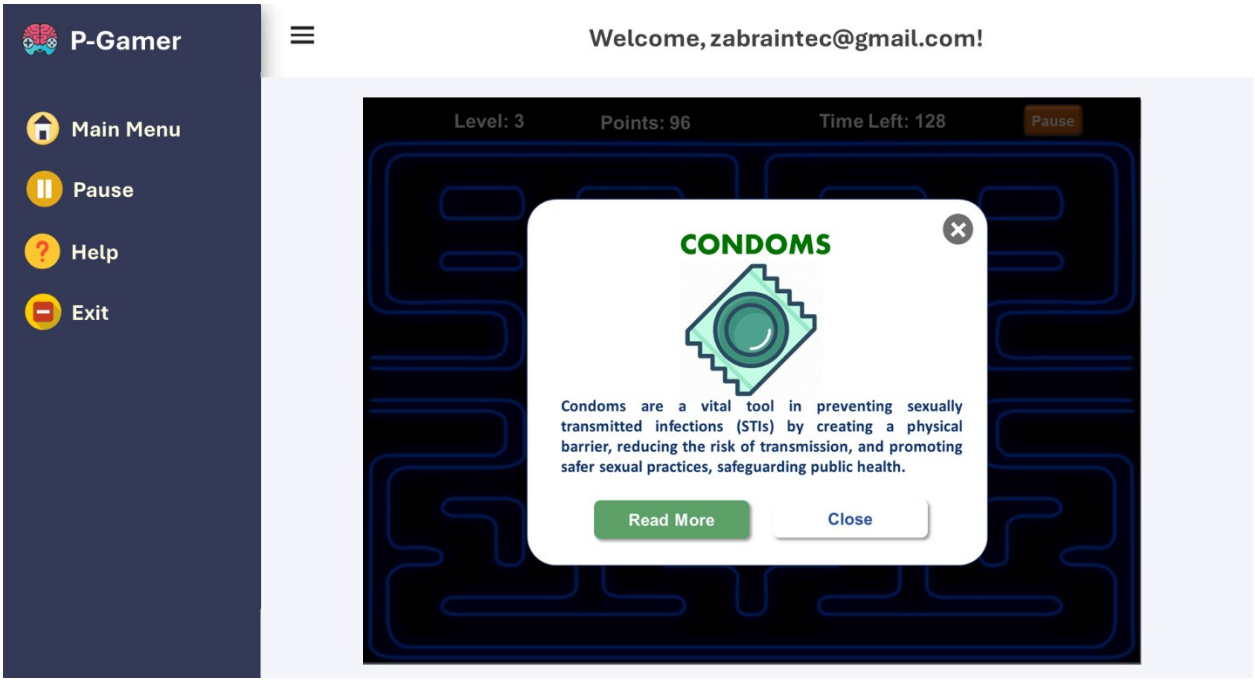
Praise Strategy 2



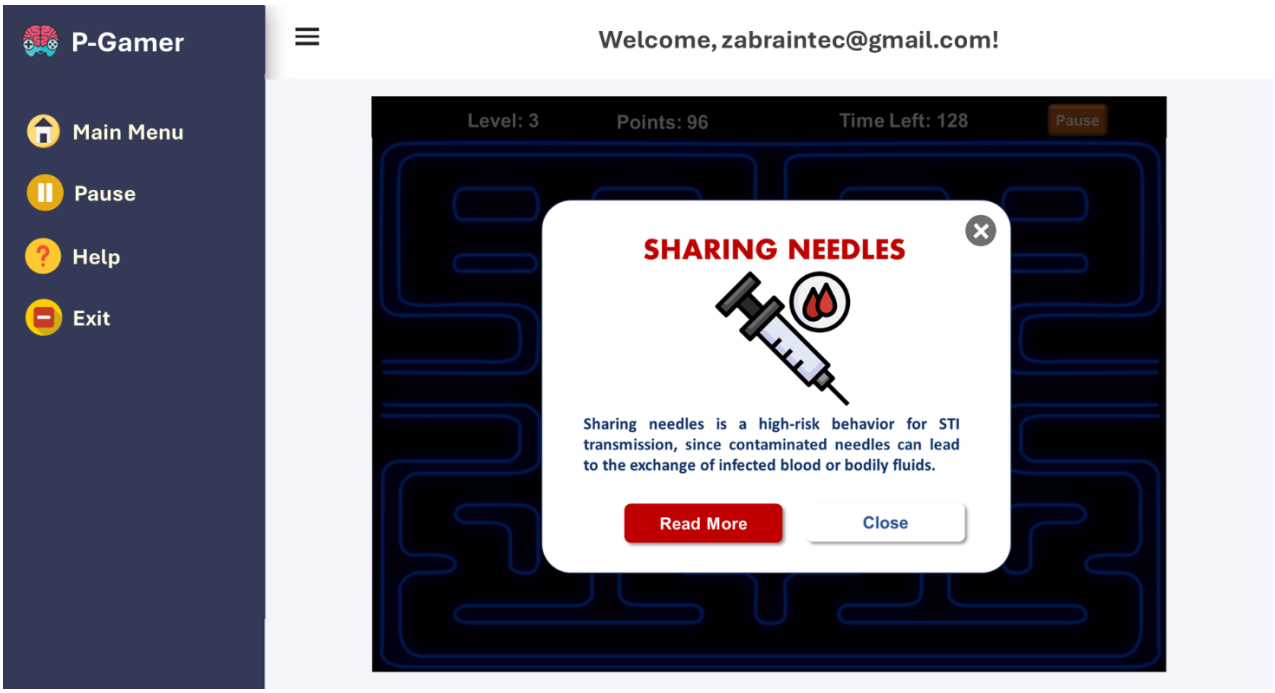
Suggestion Strategy 1 (Healthy Eating GF)



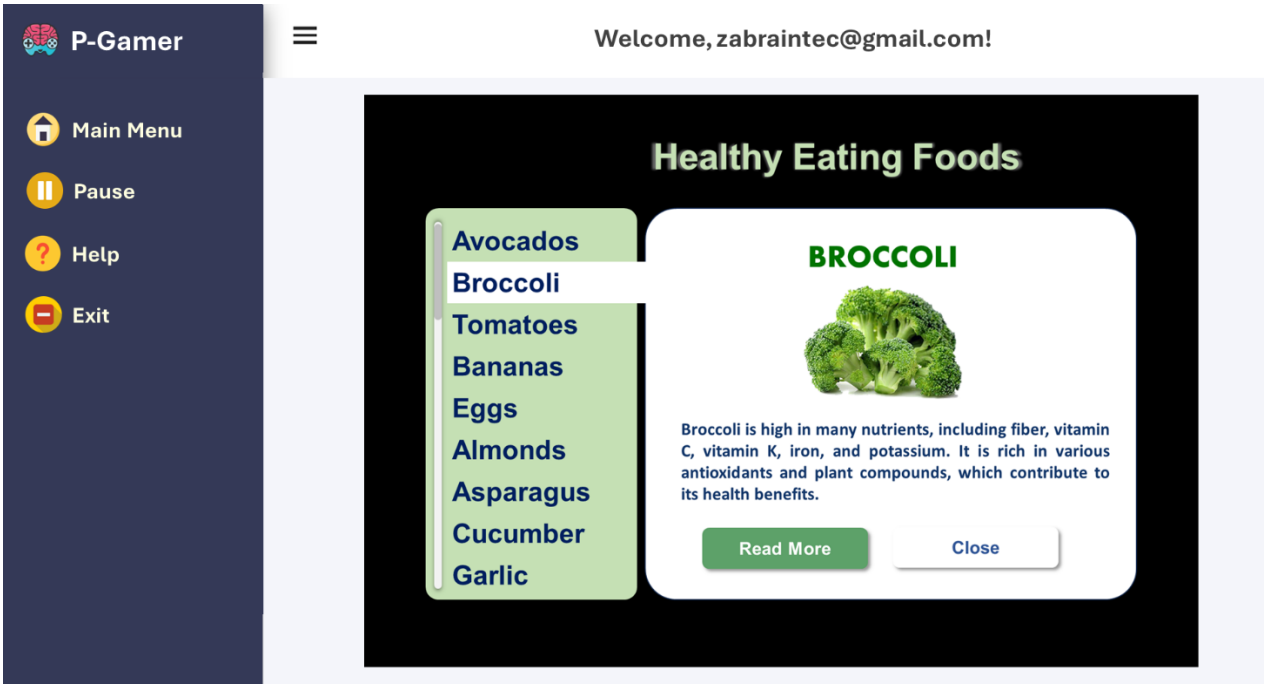
Suggestion Strategy 1 (Healthy Eating LF)



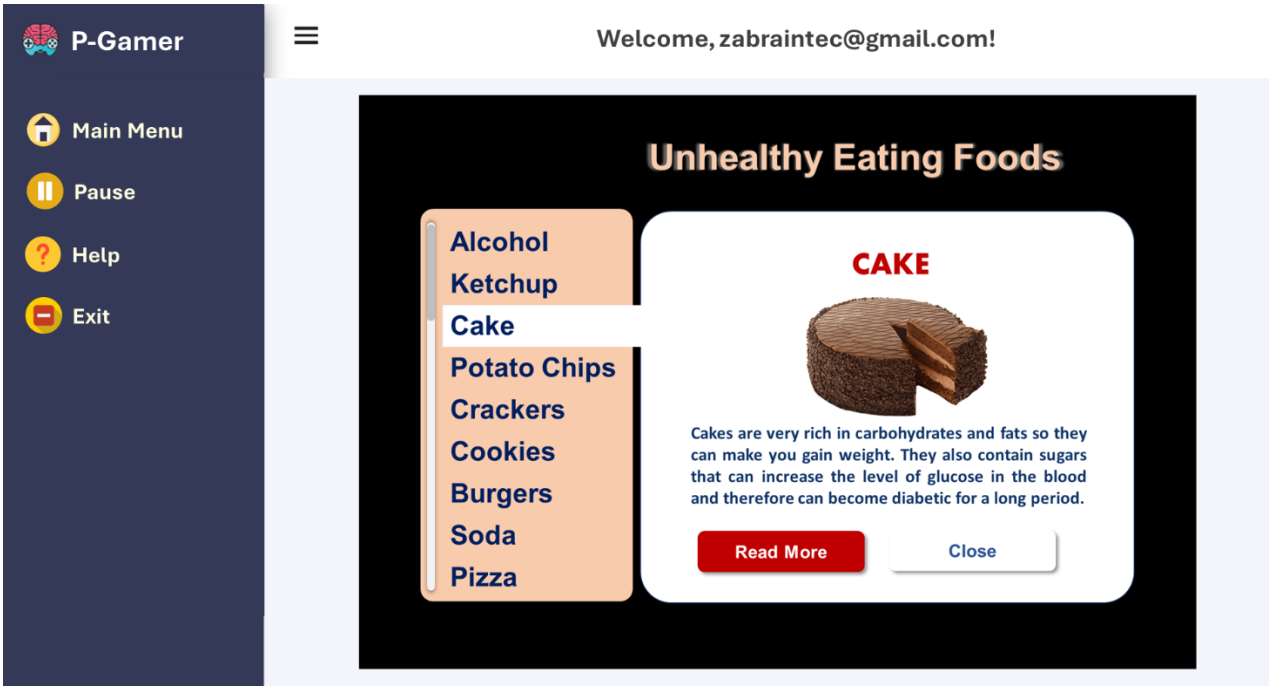
Suggestion Strategy 1 (STD Awareness GF)



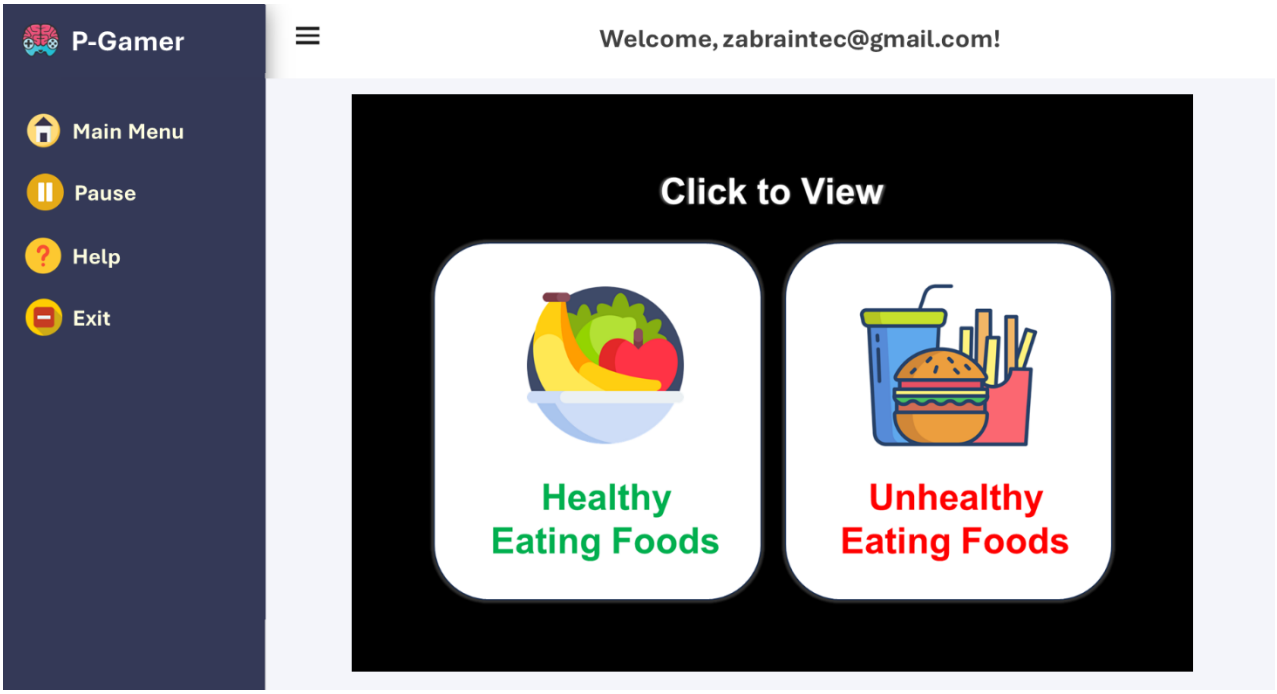
Suggestion Strategy 1 (STD Awareness LF)



Suggestion Strategy 2 (STD Awareness GF)

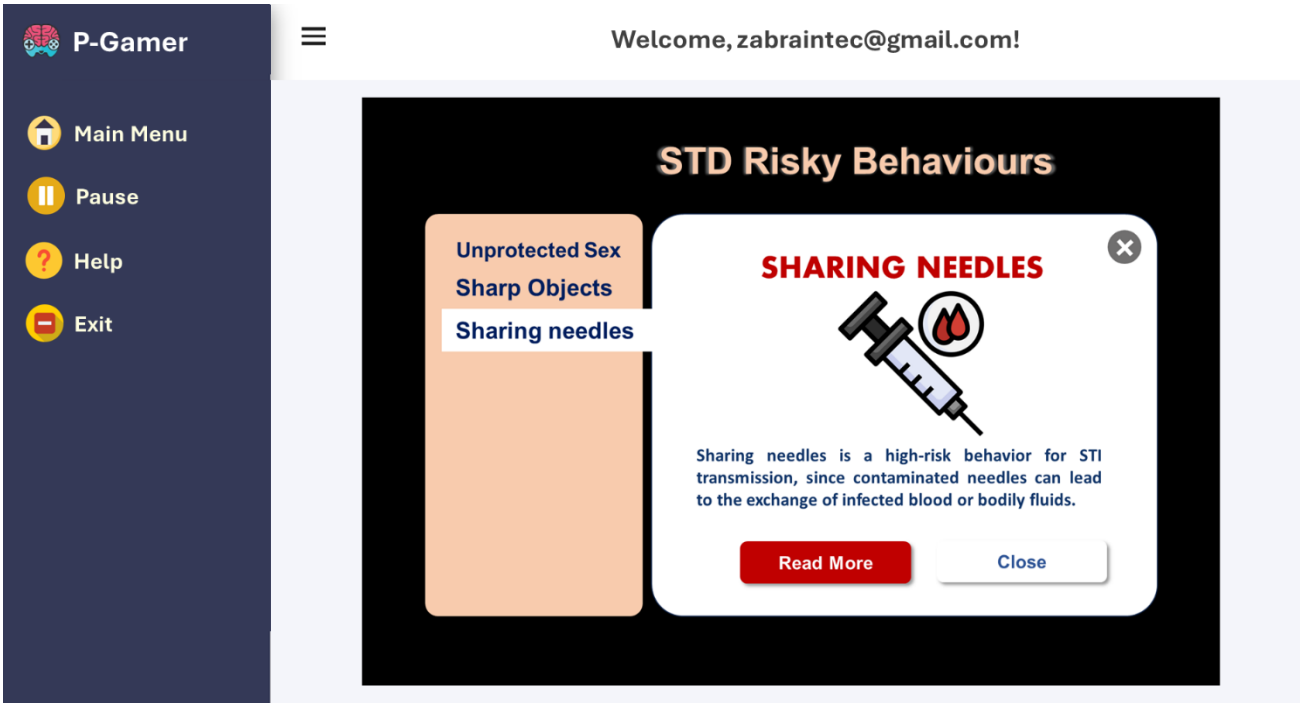


Suggestion Strategy 2 (Healthy Eating LF)

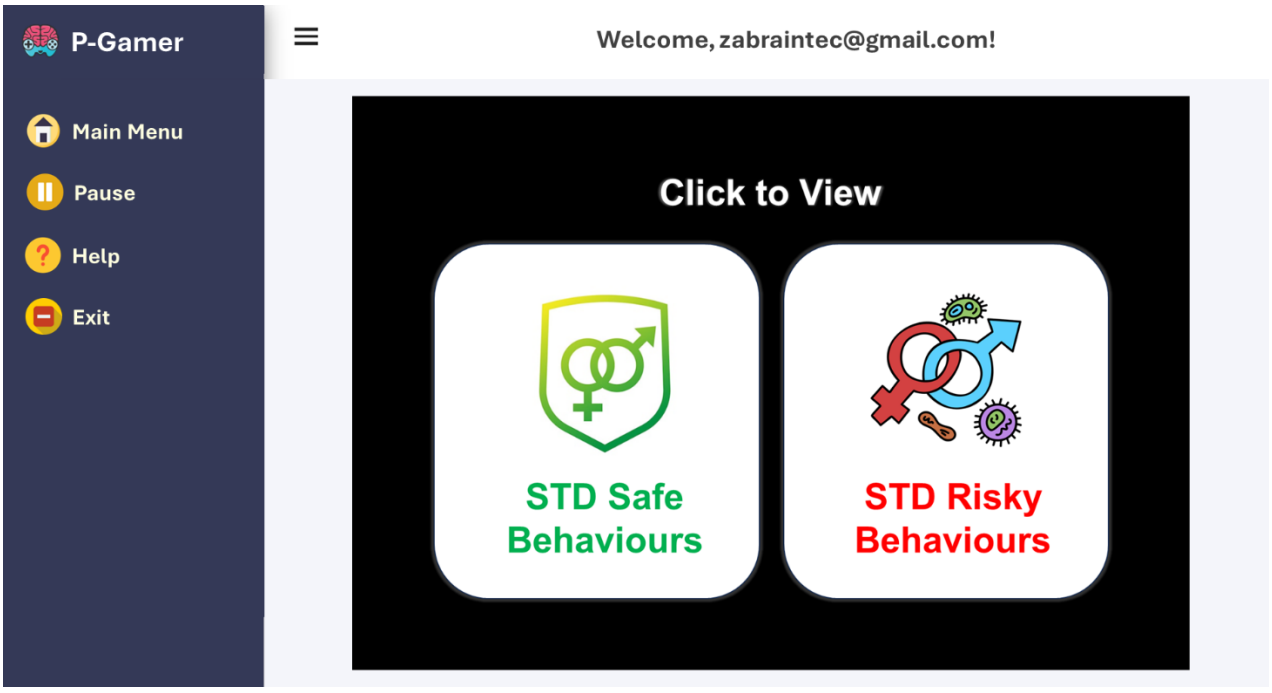


Suggestion Strategy 2 (Healthy Eating GLF)

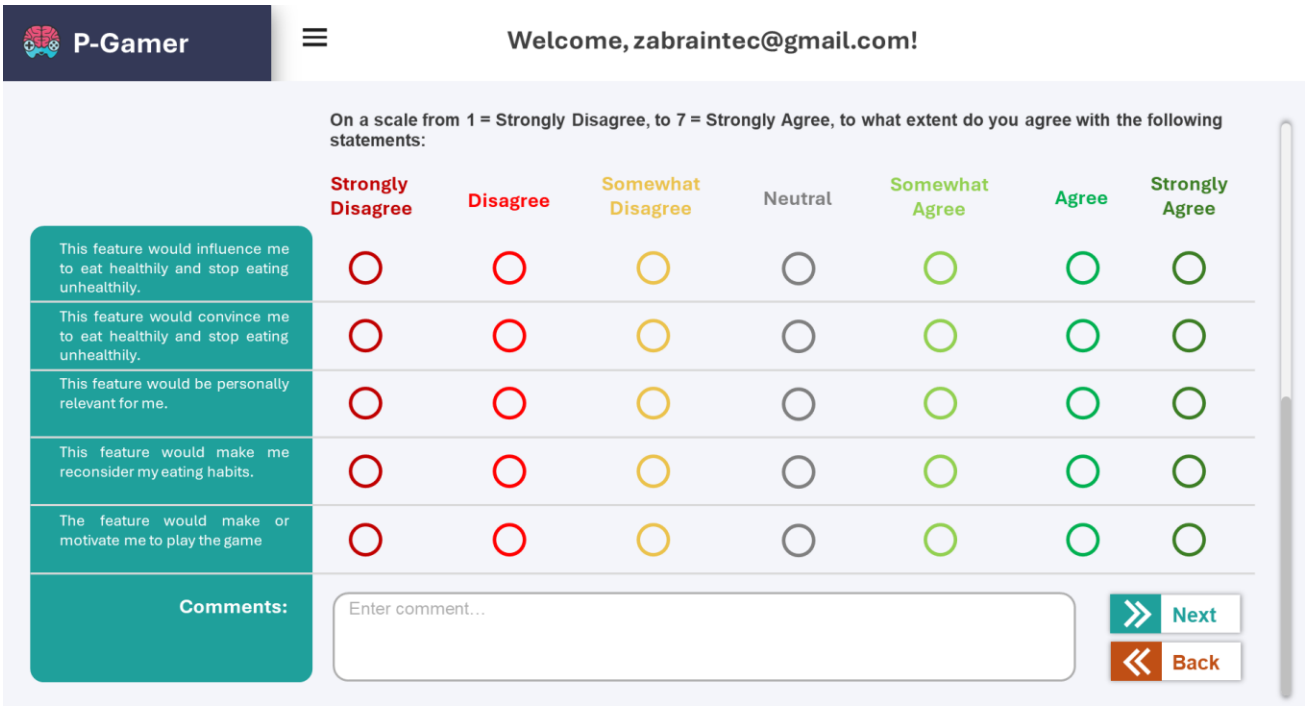
Suggestion Strategy 2 (STD Awareness GF)



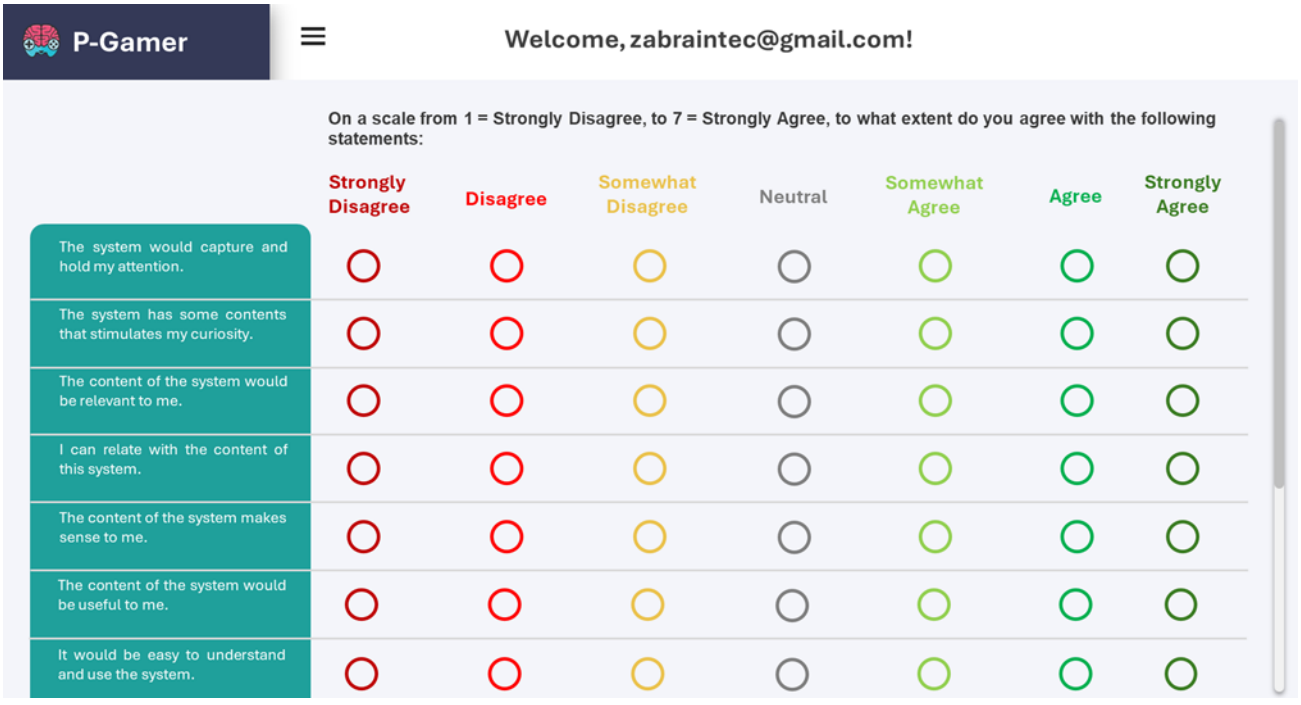
Suggestion Strategy 2 (STD Awareness LF)



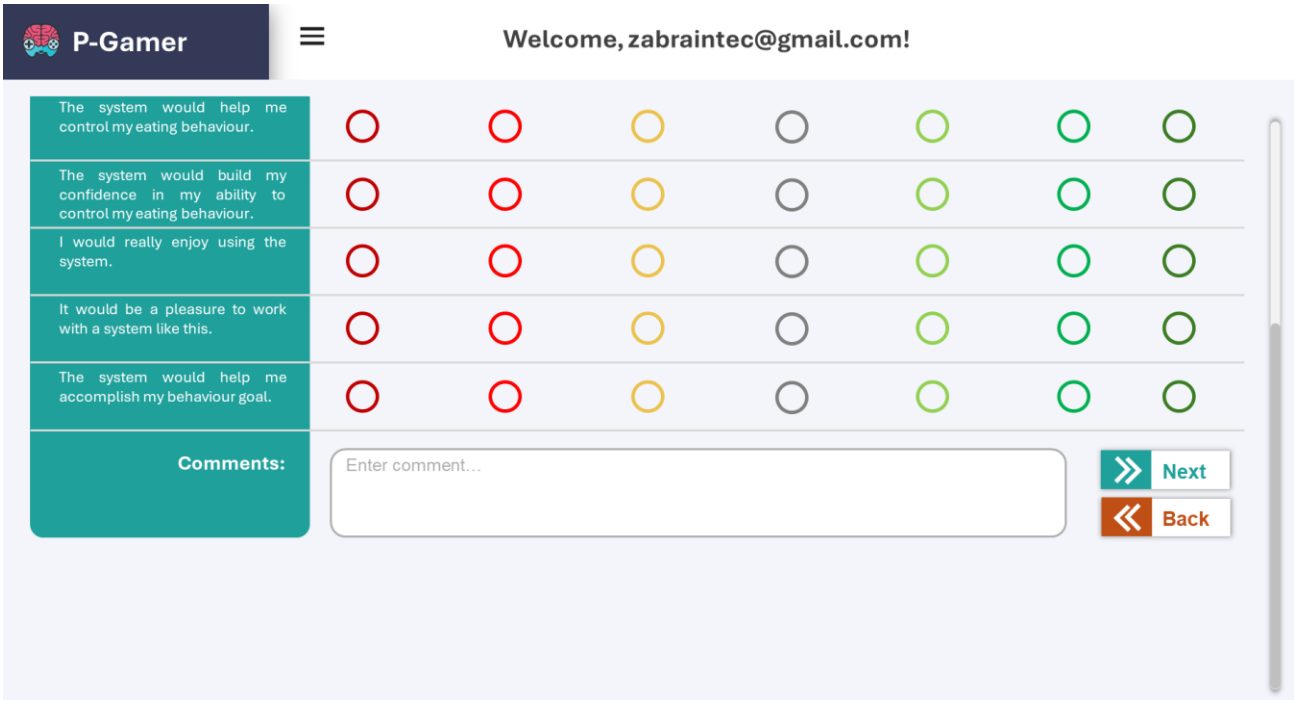
Suggestion Strategy 2 (STD Awareness GLF)



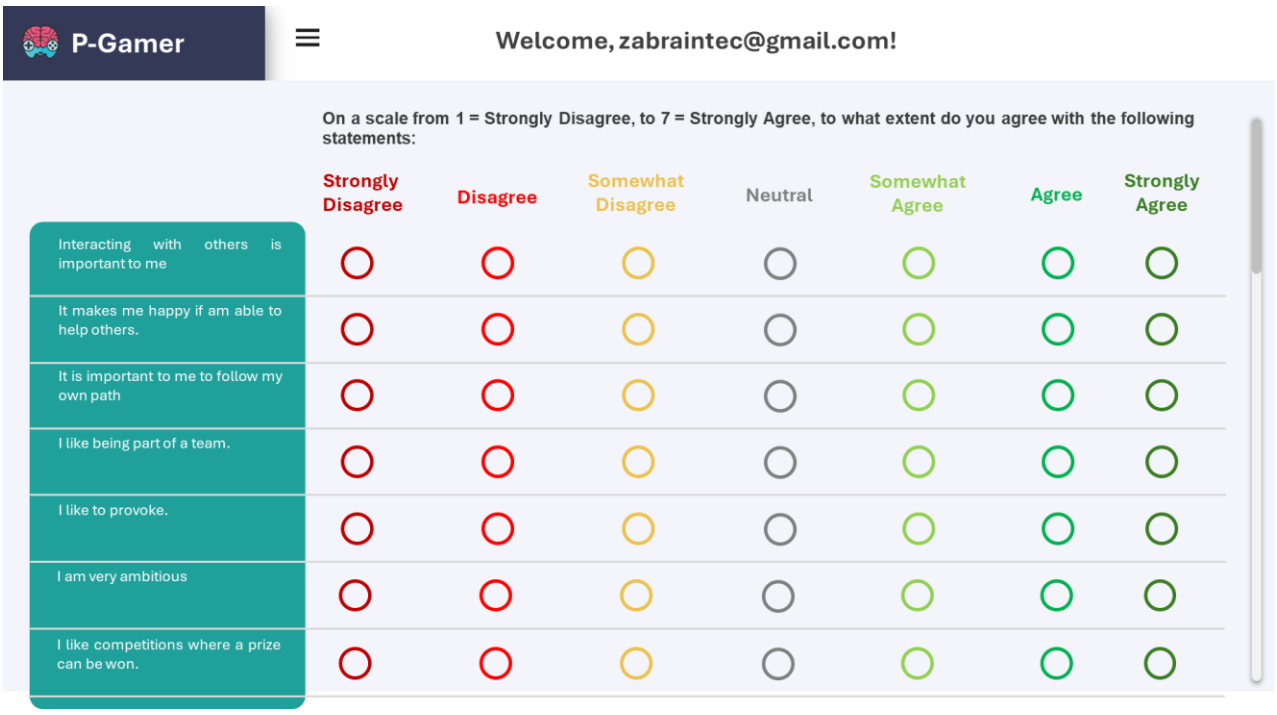
The Percieved Persuasiveness Scale



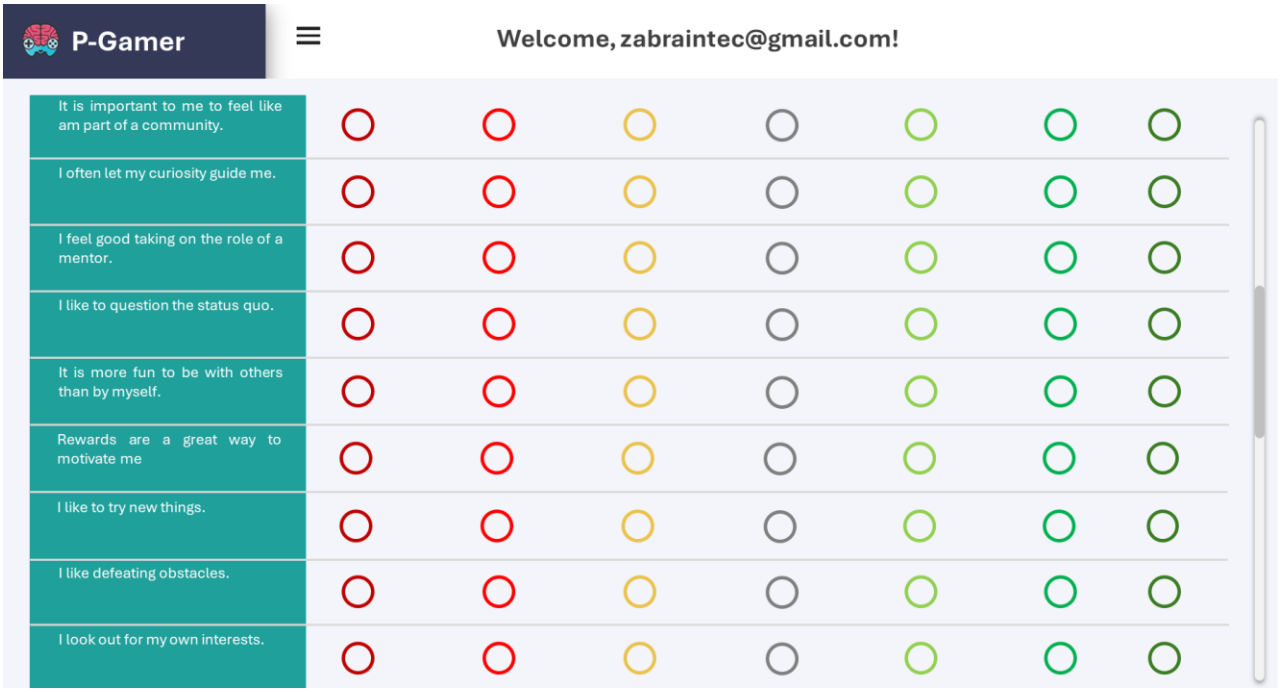
The ARCS Motivational Appeal Scale (1 of 2)



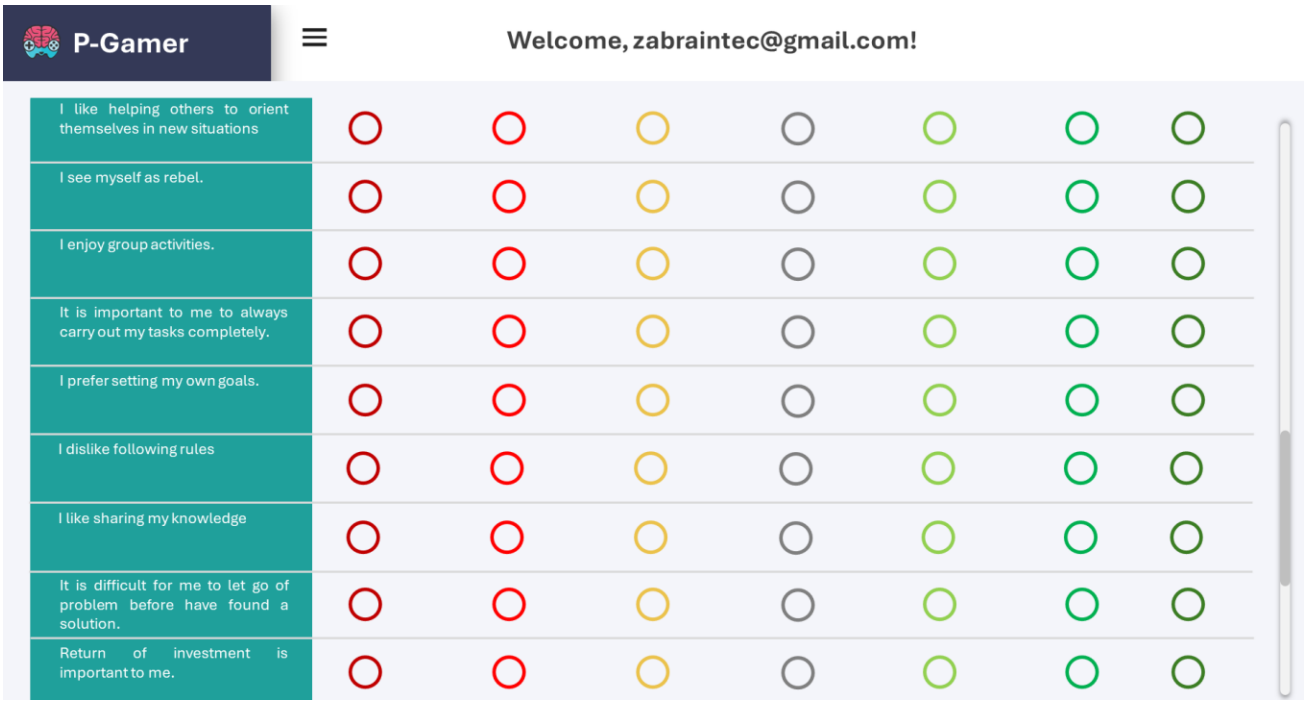
The ARCS Motivational Appeal Scale (2 of 2)



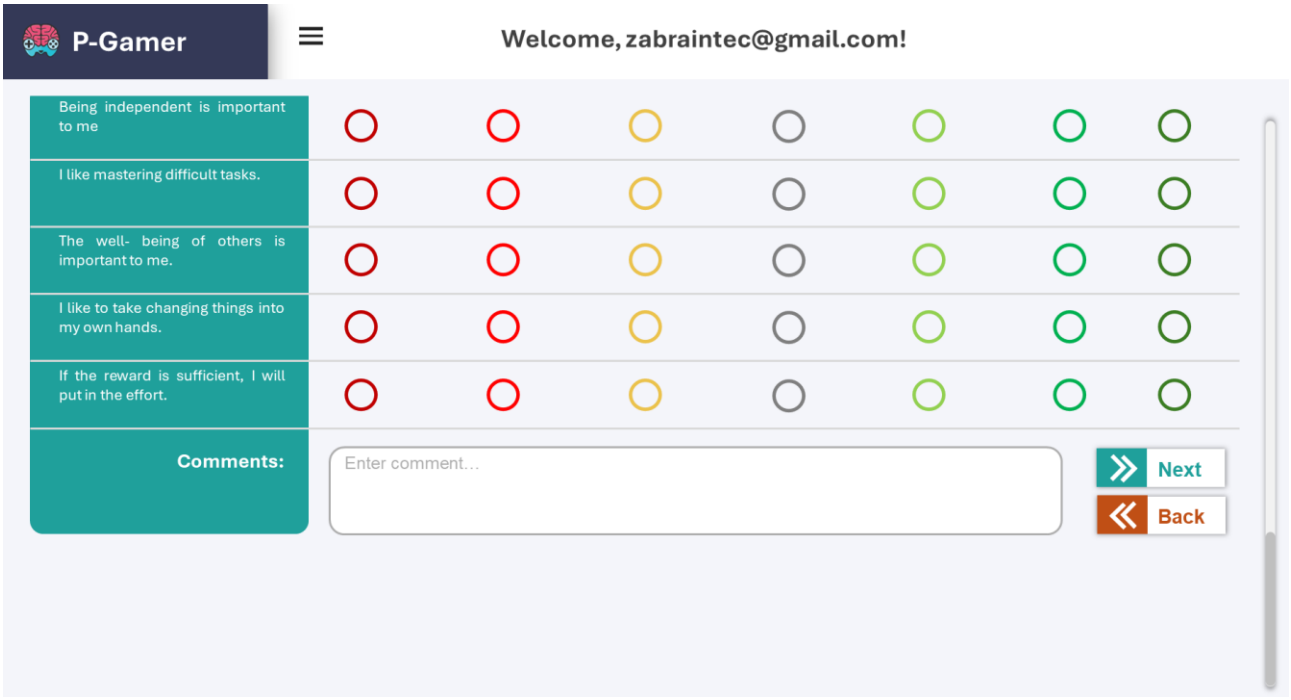
The HEXAD Gamer Type Scale (1 of 4)



The HEXAD Gamer Type Scale (2 of 4)



The HEXAD Gamer Type Scale (3 of 4)



The HEXAD Gamer Type Scale (4 of 4)

APPENDIX C. Measurement Validity and Reliability checks for the Motivational Appeal Study (Chapter 5)

Cronbach's alpha, Composite Reliability, AVE, and HTMT of the model for the Motivational Appeal Study (Measurement Validity and Reliability checks).

Validity and Reliability checks for the Gain Framing version

Gain Framing			
Variables	Cronbach Alpha	Composite Reliability	AVE
Threshold	≥ 0.7	≥ 0.7	≥ 0.5
Reward	0.781	0.853	0.759
Competition	0.828	0.901	0.696
Praise	0.841	0.812	0.743
Suggestion	0.723	0.776	0.620

HTMT values for Gain Framing

	Att	**Rel**	**Con**	**Sat**	**Rew**	**Com**	**Pra**	**Sug**
Att								
Rel	0.213							
Con	0.234	0.264						
Sat	0.311	0.228	0.241					
Rew	0.209	0.154	0.245	0.274				
Com	0.370	0.240	0.222	0.252	0.394			
Pra	0.401	0.302	0.253	0.299	0.357	0.515		
Sug	0.384	0.188	0.296	0.294	0.505	0.686	0.730	

Att = Attention, Rel = Relevance, Con = Confidence, Sat = Satisfaction, Com = Competition, Rew = Reward, Pra = Praise, Sug = Suggestion.

Validity and Reliability checks for the Loss Framing version

Loss Framing			
Variables	Cronbach Alpha	Composite Reliability	AVE
Threshold	≥ 0.7	≥ 0.7	≥ 0.5
Reward	0.822	0.865	0.81
Competition	0.847	0.907	0.779
Praise	0.843	0.838	0.592
Suggestion	0.738	0.774	0.792

HTMT values for Loss Framing

	Att	**Rel**	**Con**	**Sat**	**Rew**	**Com**	**Pra**	**Sug**
Att								
Rel	0.341							
Con	0.399	0.603						
Sat	0.166	0.303	0.463					
Rew	0.206	0.301	0.178	0.273				
Com	0.300	0.671	0.29	0.266	0.449			
Pra	0.382	0.398	0.388	0.393	0.585	0.274		
Sug	0.424	0.520	0.252	0.5	0.353	0.461	0.693	

Att = Attention, Rel = Relevance, Con = Confidence, Sat = Satisfaction, Com = Competition, Rew = Reward, Pra = Praise, Sug = Suggestion.

Validity and Reliability checks for the Gain-Loss Framing version

Gain-Loss Framing			
Variables	Cronbach Alpha	Composite Reliability	AVE
Threshold	≥ 0.7	≥ 0.7	≥ 0.5
Reward	0.883	0.953	0.611
Competition	0.856	0.874	0.689
Praise	0.813	0.893	0.760
Suggestion	0.950	0.93	0.808

HTMT values for Gain-Loss Framing

	Att	**Rel**	**Con**	**Sat**	**Rew**	**Com**	**Pra**	**Sug**
Att								
Rel	0.567							
Con	0.615	0.201						
Sat	0.65	0.416	0.514					
Rew	0.264	0.476	0.489	0.675				
Com	0.494	0.304	0.475	0.664	0.188			
Pra	0.285	0.202	0.339	0.529	0.695	0.599		
Sug	0.331	0.44	0.44	0.317	0.658	0.552	0.604	

Att = Attention, Rel = Relevance, Con = Confidence, Sat = Satisfaction, Com = Competition, Rew = Reward, Pra = Praise, Sug = Suggestion.

APPENDIX D. Measurement Validity and Reliability checks for the Gamer Type (Chapter 6)

Cronbach's alpha, Composite Reliability, AVE, and HTMT of the model for the Gamer Type Study (Measurement Validity and Reliability checks).

Validity and Reliability checks for the Gain Framing version

Gain Framing			
Variables	Cronbach Alpha	Composite Reliability	AVE
Threshold	≥ 0.7	≥ 0.7	≥ 0.5
Reward	0.93	0.701	0.612
Competition	0.788	0.813	0.584
Praise	0.713	0.922	0.792
Suggestion	0.869	0.863	0.630

HTMT values for Gain Framing

	Ach	**Soc**	**Phi**	**Fre**	**Pla**	**Dis**	**Rew**	**Com**	**Pra**	**Sug**
Ach										
Soc	0.204									
Phi	0.267	0.368								
Fre	0.685	0.251	0.408							
Pla	0.426	0.701	0.565	0.328						
Dis	0.506	0.156	0.338	0.275	0.257					
Rew	0.24	0.513	0.417	0.425	0.389	0.187				
Com	0.514	0.342	0.424	0.201	0.405	0.318	0.687			
Pra	0.317	0.34	0.529	0.614	0.472	0.44	0.457	0.471		
Sug	0.56	0.276	0.453	0.334	0.213	0.191	0.433	0.36	0.364	

Ach = Achiever, Soc = Socializer, Phi = Philanthropist, Fre = Free Spirit, Pla = Player, Dis = Disruptor, Com = Competition, Rew = Reward, Pra = Praise, Sug = Suggestion.

Validity and Reliability checks for the Loss Framing version

Loss Framing			
Variables	Cronbach Alpha	Composite Reliability	AVE
Threshold	≥ 0.7	≥ 0.7	≥ 0.5
Reward	0.776	0.897	0.746
Competition	0.817	0.88	0.697
Praise	0.721	0.759	0.765
Suggestion	0.919	0.789	0.672

HTMT values for Loss Framing

	Ach	**Soc**	**Phi**	**Fre**	**Pla**	**Dis**	**Rew**	**Com**	**Pra**	**Sug**
Ach										
Soc	0.563									
Phi	0.26	0.464								
Fre	0.252	0.581	0.607							
Pla	0.155	0.409	0.21	0.468						
Dis	0.572	0.468	0.382	0.547	0.38					
Rew	0.247	0.245	0.309	0.467	0.525	0.181				
Com	0.48	0.476	0.331	0.568	0.341	0.321	0.522			
Pra	0.534	0.358	0.481	0.61	0.68	0.565	0.637	0.422		
Sug	0.488	0.548	0.153	0.536	0.385	0.637	0.371	0.701	0.163	

Ach = Achiever, Soc = Socializer, Phi = Philanthropist, Fre = Free Spirit, Pla = Player, Dis = Disruptor, Com = Competition, Rew = Reward, Pra = Praise, Sug = Suggestion.

Validity and Reliability checks for the Gain-Loss Framing version

Gain-Loss Framing			
Variables	Cronbach Alpha	Composite Reliability	AVE
Threshold	≥ 0.7	≥ 0.7	≥ 0.5
Reward	0.907	0.725	0.729
Competition	0.929	0.869	0.621
Praise	0.702	0.732	0.627
Suggestion	0.944	0.864	0.634

HTMT values for Gain-Loss Framing

	Ach	**Soc**	**Phi**	**Fre**	**Pla**	**Dis**	**Rew**	**Com**	**Pra**	**Sug**
Ach										
Soc	0.249									
Phi	0.186	0.245								
Fre	0.61	0.571	0.597							
Pla	0.351	0.328	0.298	0.593						
Dis	0.534	0.395	0.534	0.477	0.359					
Rew	0.45	0.57	0.53	0.173	0.296	0.226				
Com	0.181	0.165	0.524	0.511	0.428	0.256	0.317			
Pra	0.545	0.225	0.689	0.373	0.606	0.318	0.591	0.507		
Sug	0.177	0.358	0.568	0.595	0.317	0.538	0.486	0.584	0.523	

Ach = Achiever, Soc = Socializer, Phi = Philanthropist, Fre = Free Spirit, Pla = Player, Dis = Disruptor, Com = Competition, Rew = Reward, Pra = Praise, Sug = Suggestion.

APPENDIX E. PERMISSION TO USE

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6050 University Ave,
Dalhousie University,
Halifax, Nova Scotia, Canada B3H 1W5

APPENDIX F. Ethics Approval

Social Sciences & Humanities Research Ethics Board
Letter of Approval

June 15, 2020
Chinenye Ndulue
Computer Science\Computer Science

Dear Chinenye,

REB #: 2020-5165
Project Title: Investigating the Implementations of Persuasive Strategies Across and Within Domains

Effective Date: June 15, 2020
Expiry Date: June 15, 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 issued by Dalhousie University (or other facilities where the research will occur) regarding preventing the spread of COVID-19.

Sincerely,

APPENDIX G. LIST OF MY PUBLICATIONS

1. **Chinenye Ndulue** and Rita Orji. 2024. The Impact of Persuasive Framing on the Perceived Effectiveness of a Game for Behaviour Change. International Journal of Human–Computer Interaction: 1–15. https://doi.org/10.1080/10447318.2024.2355390

2. Ravishankar Subramani Iyer, **Chinenye Ndulue**, Sandra Meier, and Rita Orji. 2024. Smartphone Games Heuristics (SmGH) – Towards a Standard Set of Platform-Centric Heuristic for Smartphone Games Evaluation. International Journal of Human–Computer Interaction: 1–22. https://doi.org/10.1080/10447318.2024.2356911

3. **Ndulue, C**., Orji, R. (2024). Exploring the Influence of Game Framing and Gamer Types on the Effectiveness of Persuasive Games. In: Baghaei, N., Ali, R., Win, K., Oyibo, K. (eds) Persuasive Technology. PERSUASIVE 2024. Lecture Notes in Computer Science, vol 14636. Springer, Cham. https://doi.org/10.1007/978-3-031-58226-4_16

4. Orji, J., Chan, G., **Ndulue, C.**, Orji, R. (2024). SmileApp: The Design and Evaluation of an mHealth App for Stress Reduction Through Artificial Intelligence and Persuasive Technology. In: Baghaei, N., Ali, R., Win, K., Oyibo, K. (eds) Persuasive Technology. PERSUASIVE 2024. Lecture Notes in Computer Science, vol 14636. Springer, Cham. https://doi.org/10.1007/978-3-031-58226-4_18

5. Anukem, S., **Ndulue, C.**, Orji, R. (2024). DROP DASH: A Persuasive Mobile Game to Promote Healthy Hydration Choices Using Machine Learning. In: Baghaei, N., Ali, R., Win, K., Oyibo, K. (eds) Persuasive Technology. PERSUASIVE 2024. Lecture Notes in Computer Science, vol 14636. Springer, Cham. https://doi.org/10.1007/978-3-031-58226-4_5

6. Alqahtani, F., **Ndulue, C.**, Orji, R. (2024). Exploring the Effect of Using a Single Versus Multiple Behaviour Change Strategies on Motivation to Use Gratitude App and Possible Gender Differences. In: Baghaei, N., Ali, R., Win, K., Oyibo, K. (eds) Persuasive Technology. PERSUASIVE 2024. Lecture Notes in Computer Science, vol 14636. Springer, Cham. https://doi.org/10.1007/978-3-031-58226-4_3

7. **Chinenye Ndulue** and Rita Orji. 2023. A Usability Evaluation of a Software Framework for Designing Persuasive Games. In Adjunct Proceedings of the 31st ACM Conference on User Modeling, Adaptation and Personalization (UMAP '23 Adjunct). Association for Computing Machinery, New York, NY, USA, 123–128. https://doi.org/10.1145/3563359.3596988

8. Anirudh Ganesh, **Chinenye Ndulue**, and Rita Orji. 2023. Tailoring a Persuasive Game to Promote Secure Smartphone Behaviour. In Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23). Association for Computing Machinery, New York, NY, USA, Article 618, 1–18. https://doi.org/10.1145/3544548.3581038

9. **C. Ndulue** and R. Orji, "Persuasive Games for Physical Activity in App Stores: A Systematic Review," 2022 IEEE 10th International Conference on Serious Games and Applications for Health(SeGAH), Sydney, Australia, 2022, pp. 1-6. https://doi.org/10.1109/SEGAH54908.2022.9978574

10. **Ndulue, C.**, Melis, M., & Orji, R. (2022). Nutri-Smober: A Preliminary Study to Investigate the Domain Dependency of Behaviour Change Strategies in Persuasive Games. CHI PLAY 2022 - Extended Abstracts of the 2022 Annual Symposium on Computer-Human Interaction in Play, 2–7. https://doi.org/10.1145/3505270.3558336

11. **C. Ndulue** and R. Orji, "Games for Change - A Comparative Systematic Review of Persuasive Strategies in Games for Behaviour Change," in IEEE Transactions on Games, https://doi.org/10.1109/TG.2022.3159090

12. **Ndulue, C.**, Orji, R. (2022). Player Personality Traits and the Effectiveness of a Persuasive Game for Disease Awareness Among the African Population. In: Baghaei, N., Vassileva, J., Ali, R., Oyibo, K. (eds) Persuasive Technology. PERSUASIVE 2022. Lecture Notes in Computer Science, vol 13213. Springer, Cham. https://doi.org/10.1007/978-3-030-98438-0_11

13. **Ndulue, C.**, Oyebode, O., Iyer, R. et al. Personality-targeted persuasive gamified systems: exploring the impact of application domain on the effectiveness of behaviour change strategies. User Model User-Adap Inter 32, 165–214 (2022). https://doi.org/10.1007/s11257-022-09319-w

14. Oyebode, O., **Ndulue, C.,** Mulchandani, D., Suruliraj, B., Adib, A., Orji, F. A., Milios, E., Matwin, S., & Orji, R. (2022). COVID-19 Pandemic: Identifying Key Issues Using Social Media and Natural Language Processing. Journal of Healthcare Informatics Research. https://doi.org/10.1007/S41666-021-00111-W

15. Ganesh, A., **Ndulue, C.**, Orji, R. (2022). Smartphone Security and Privacy – A Gamified Persuasive Approach with Protection Motivation Theory. In: Baghaei, N., Vassileva, J., Ali, R., Oyibo, K. (eds) Persuasive Technology. PERSUASIVE 2022. Lecture Notes in Computer Science, vol 13213. Springer, Cham. https://doi.org/10.1007/978-3-030-98438-0_7

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