Developing a Gamified Behavior Change Support System: Case Implicity – The Food Game

Iikka Manninen[1] and Piiastiina Tikka[✉,1]

[1] University of Oulu, Pentti Kaiteran katu 1, Oulu, Finland
piiastiina.tikka@oulu.fi

Abstract. This paper describes the development process of a gamified mobile Behavior Change Support System for increasing its users' fruit and vegetable consumption. The system was based on the principles of implicit association measures as the behavioral feedback for reflection. The project used the Persuasive Systems Design (PSD) together with gamification principles and the Implicit Association Test (IAT). The present paper describes the background and process of implementing IAT in a gamified form for a mobile device platform. Key outputs from the process include perceiving such a system to be built of a basic BCSS core which is then gamified, and identifying a system to have segments that each have their own relevant persuasive features.

Keywords: Gamification, PSD, BCSS, Implicit association, behavior change, systems development

1 Introduction

When building behavior change interventions that are based on self-tracking, the approach is typically to keep track of some specific *behavior* or *activity*. Today's technology allows behavior and performance tracking directly, using the various sensors that are now readily available in just about any smartphone. Alternatively, activities and behavior can be tracked by self-reported means, for example by writing a food diary. This approach focuses, necessarily, on what a person is already doing or has completed doing – the person is already engaged with the target behavior. However, it is perhaps possible to expand tracking-based behavior change to include attitudes and automatic thinking in an effort to support actual behavior. Awareness of our own thinking and attitudes, arising from implicit attitude measures, offers a means to engage in reflection on our own behavior even at times when not engaging in that behavior. Such awareness can also allow rehearsing target behaviors and responses to stimuli in a safe and controlled manner so that we can be ready when a real situation arises.

In the present paper we describe the development steps leading to the creation of a gamified Behavior Change Support System (BCSS)[1] for promoting fruit and vegetable consumption. Using Persuasive Systems Design (PSD) [2] model as the design framework and to guide the development process, we analyzed and evaluated requirements for a system that would offer an engaging rehearsal environment for the target behavior. The system employed implicit measures of existing attitudes (automatic responses) in triggering self-reflection, and allowed response rehearsal as regards food item responses through gamified rehearsal.

2 Background

2.1 Implicit Measures of Attitude and Cognitive Dissonance Theory

Implicit association test (IAT) was first presented in a paper by Greenwald, McGhee and Schwartz [3] as a means for measuring implicit attitudes (attitudes that result from automatic evaluations not under the control of an individual). In their original paper, Greenwald et al. [3] posited that IAT would be able to reveal attitudes or automatic associations that would be otherwise unavailable because of variety of reasons. IAT has been utilized in a wide variety of domains: a meta-analysis on predictive validity of IAT [4] included nine different domains from intergroup behavior to consumer preferences, and found that there was variance between the domains. in socially sensitive topics, IAT's validity was significantly higher compared to self-report measures [4].

A modified version of the IAT called EAST was used to investigate whether differences in implicit attitudes toward healthy and unhealthy food existed among obese children and a control group [5]. The study found that obese children did not have an implicit preference to unhealthy food; however, their implicit attitude towards both healthy and unhealthy food was greater than what it was in the control group. A study into implicit and explicit attitudes towards high-fat foods in obese persons and a control group indicated that implicit attitude in obese subjects towards high-fat foods was more negative than in the control group [6]. The IAT score has also been found to correlate with dieting activity: participants who according to their self-reported behavior restricted their intake of high calorie food also had implicit attitudes that favored low calorie products [7]. Finally, a study investigating whether IAT can be used as a predictor of food choice found a small but significant effect of IAT being able to predict behavioral food choice [8]. The above-mentioned studies point to cases where IAT has been used in the study of implicit attitudes with regards to food. Where predicting behavior may not always be a straight-forward affair as in [6], the studies illustrate that food and nutrition can be observed through implicit measures.

In the development of the application described in this paper, we build the behavior change potential on self-reflection. As regards self-reflection's role in behavior change, one theory that may help in part explain its effectiveness is the cognitive dissonance theory [9], which posits that when a person encounters information that does not match his or her present state of cognition, the resulting state of imbalance is so uncomfortable that the person will try to reduce the dissonance. In the present gamified BCSS the player is given a score based on his or her response times to common food items (positive or negative categorization). The higher the score, the more in line the player is with the target attitude of associating healthier food items with positive words. However, if the scores are consistently poor, the player is presented with information that his or her food associations do not match the expectation. The player sees how his or her thinking is skewed to favor the less-than-healthy food items. The player must, then, evaluate whether to accept this information and try to change their behavior or to reject it entirely and carry on as always. The information is, however, based on an implicit measure that is difficult to explain away – it is not a result of external factors or influenced by other people – which, we assume, makes the rejection more difficult.

2.2 Gamification

In their systematic survey of gamification, Seaborn and Fels [10] define gamification "as the use of game elements and mechanics in non-game contexts" (p. 16). In their seminal paper on gamification, Deterding, Dixon, Khaled and Nacke [11] define gamification as "the use of game design elements in non-game contexts". Gamification has also been described as "process of game-thinking and game mechanics to engage users and solve problems" [12] and as the "use of game elements and game-design techniques in non-game contexts" [13].

Many alternative, yet distinct, terms related to gamification exist [11]. Some examples of these are "productivity games, surveillance entertainment, behavioral games and applied gaming" [10]. One prominent concept is serious games, which encompasses game software that has been developed with an intention to be more than entertainment. The purpose of serious game is to provide learning material that is played through [11]. As Seaborn and Fels [10] advocate that gamified systems use game elements but are not games, and Detering et al. [11] point out that it is impossible to know whether a system is a game or a gamified application without knowing the designer's intentions or without knowing how the users perceive a system, we propose in the present paper to define the developed application to be a gamified BCSS to the design intention.

Deterding et al. [11] describe five levels of game design. The most concrete level is interface design patterns, followed by game design patterns and game mechanics. More abstract levels of game design elements are game design principles and heuristics, game models and game design methods. Werbach and Hunter [13] define game design to be a combination of science, art and experience and compare it to strategic leadership or team management.

Game elements are normally expected to be used as parts of an entertainment game. Gamification aims to use these elements to improve user experience in other contexts, or as used in the definition, non-game contexts. Deterding et al. [11] explicitly instruct to not place limitations on what these contexts may be. Werbach and Hunter [13] define non-game contexts to mean internal, external or behavior-change situations. In their definition, these situations involve business in the real world or goals with social impact.

Points, badges and leaderboards are widely a used implementation of gamification. They have been criticized as being a stock approach to gamification called "pointsification" [10]. The main purpose of points is to keep score, determine win states, create connection between game progression and extrinsic rewards, provide feedback, show an external display of progress and provide data for the game's designer. A badge represents an achievement within the game and they are often used as a substitute for achievements; Leaderboards provide a way to see progress in ways that points or badges are not able to [13]. For instance, a leaderboard can show progress in comparison to other users of the gamified application. Other common elements include progression, status, levels, rewards and roles.

When purpose of gamification is considered, the concepts of motivation, behavior change and engagement were a common theme [10]. Additionally, the reviewed literature [10] agreed in three areas: design theory, theoretical constructs and theoretical framework. For design theory, user-centered design was consistently applied. The main theoretical constructs were intrinsic and extrinsic motivation, which are grounded in self-determination theory [10].

According to a literature review conducted by Mora et al. [14], the Six Steps to Gamification framework by Werbach and Hunter is the best known framework and that many other frameworks are based on it. Werbach and Hunter [13] point out that implementing gamification requires constant testing and iteration to see which aspects of the system and its design work and which do not. Playtesting, analytics and interviews are some of the ways that can be used to aid the design process.

3 Case Description

The software artifact we developed is based on the Implicit Association Test (IAT) as given by Project Implicit [15] and the central idea was to build a gamified version of the IAT for the purpose of using the IAT format as a means for the user to track his or her responses to aid in self-reflection and self-monitoring. This chapter describes the design and development process of the application. A Persuasive Systems Design (PSD) [2] analysis was performed to identify important issues and to select relevant software features to be included in the application, followed by iterative rounds of development from mock-up and prototype development leading into finalizing the application release.

3.1 Persuasion Context Analysis

The PSD model [2] was used to analyze the persuasion context. It was also used to select design features that would be implemented in the application.

Intent. The persuader of the application can be viewed from two different angles. First, as the application's premise originates from an information processing science researcher, the researcher can be thought to be the persuader of the application. The alternative way is to assign the role of persuader to the user of the application, having chosen to use a system aiming at promoting behavior change. In this approach the gamification principles are an important element as they should preferably be able to encourage the user to keep using the application for a longer period of time.

From a research perspective the intent of creating the application is to see whether a gamified implicit association test can cause user to change his or her attitude and/or behavior. In other words, it is not sufficient if the user only complies but does not ultimately change dietary habits. Since the user background may vary, formation, reinforcement and change are all relevant when considering change outcomes that are being targeted.

Event. *User Context.* The potential users of the application are all individuals who are interested in adopting healthier eating habits although it is possible that the application could be used by individuals purely interested in testing their association strengths as in the original IAT.

The user interface, textual descriptions and other central characteristics of the application can be thought to implicitly exclude certain user groups such as children or visually impaired. Because the implicit association test is based on response times to determine the strength of associations, there was a need to consider the issue of reaction times in designing the game logic to accommodate different types of users. However, to keep the technical implementation of the application more manageable it was decided that additional features such as a more personalized scoring system or social comparison features were to be left out from this iteration. For instance, more customization could have been achieved by providing customized sets of foods, adjustable difficulty level or offering the chance to provide additional information concerning long-term or short-term issues that affect dietary habits. In practice this could have meant that the user would have been able to tell whether s/he was feeling tired, happy or hungry before a game session, with the view to offering more context for self-reflection based on performance visualizations in the 'profile' part of the system.

Use context. The application provides support for adopting healthier eating habits. The game logic would be designed in a way that only correct categorizations would lead to points and being able to advance in the game. Information on healthy foods would be provided to further support behavior change. Tools that give ability to see past performances would be included.

Technology context. The base platform used in the development of this application was Cordova, a hybrid mobile application development framework. Cordova allows the developer to deploy for multiple different platforms including iOS, Android and Windows Mobile. Android was chosen as the main platform on which the application was developed and tested. The database engine used for storing user data was SQLite. The frontend was built with AngularJS, a JavaScript based single-page application framework. Other web technologies such as HTML and CSS were used whenever necessary.

Strategy. Outside game instructions, text content was used scarcely in the initial version of the application. For each healthy food, a short text containing information about health benefits was collected from various online sources. The longer references were included in the background section. A large part of the content that a player sees is based on his/her performance; the system itself does not make judgments on how the player is performing as it is only displaying data.

3.2 Persuasive Software Features

The PSD model includes four categories of persuasive system principles. From these categories, principles from primary task support, dialogue support and system credibility were included in the application. Social support features were left out of the present release of the application owing to time and resource limitations. Selection of features was based on the context analysis, guiding the selection for example by ruling out features that did not support the design goals of creating a quick and light game that will expose the players to their own automatic responses, offers repetition of task to allow users to try and improve, and offers all content in a fluent and simple manner.

The overall structure of the application can be divided into three main parts: game, profile and background information. The game section contains the gamified implicit association test. In the profile section the user can track his or her progress by looking at statistics, charts and achievements. The background section contains information on healthy eating and the application itself. For each section, a walkthrough of each category of persuasive system features was conducted to determine what features could be implemented in the application. Tables 1, 2 and 3 list the design principles included in each section.

Table 1. Design principles used in the Game section.

Persuasive feature category	Persuasive feature	Description
Primary task support	Rehearsal	Adopting healthier eating habits means choosing healthy food over unhealthy. This is the central idea of the gamified test.
	Reduction	Health information displayed after the game is in easily digestible form (e.g. language use and style).
Dialogue support	Praise	After the game praise is given if enough points are scored or achievements have been reached.
	Rewards	Virtual rewards in the form of additional content are given.

Table 2. Design principles used in the Profile section.

Persuasive feature category	Persuasive feature	Description
Primary task support	Self-monitoring	User can track progress via statistics, charts and achievements.
Dialogue support	Rewards	Achievements are shown in the profile page.

Table 3. Design principles used in the Background section

Persuasive feature category	**Persuasive feature**	**Description**
Primary task support	Reduction	Advice on healthy eating is presented in a brief manner.
System credibility support	Trustworthiness	Health information is from reliable sources.
	Authority	Quote authorities.
	Verifiability	Include links to literature and official sources when relevant.
	Expertise	Provide health information sources.

4 Development Process

Being based on the IAT, an existing construct, many technological requirements and design elements could be determined by studying the implementation available in Project Implicit's [15] website. The development process began by gathering the high-level requirements of the application from the existing implementation of IAT. These requirements were then used in selecting the appropriate technologies and frameworks used for development.

4.1 Selecting the Platform and Programming Framework

As the IAT heavily relies on measuring the user's reaction time in determining the strength of association between concepts and attributes, the technological requirement of being able to accurately measure time was a factor in framework selection. The framework's performance was also considered from the angle of persuasiveness in terms of general responsiveness, mainly start-up time, and how straightforward it was for the developer to build a user-friendly interface (Surface credibility principle [2]).

Three different platforms were compared (Table 4). The process included setting up the development environment for each framework and then building a single application that measured time between two clicks. Minor details that were included in the comparison were the application's size, application start-up time, supported operating systems, the programming languages used and the expected development time.

The data on application's size was gathered with the framework's default settings and thus does not include any optimizations that are available for applications ready for release. The start-up time was measured by touching the application icon on the phone screen and waiting until the application was loaded. In this case, it meant the appearance of a single test button and the ability for the user to interact with it. The accuracy was tested by enabling USB debugging from the phone, turning on the remote debugging features of the framework, which allowed the application to be controlled with Google Chrome browser's remote debugging tools. This was done because no straightforward way to automatically click or touch the screen within the phone was found. An auto-clicking software was then used from the desktop to determine the framework's accuracy. Based on the results, Ionic framework was dropped from the list of possible frameworks as at the time of testing the slow start-up was a known feature of the framework. A long start-up time would have negatively affected the user experience, as it would have discouraged the user from playing the game in short sessions.

Table 4. Framework Comparison

Platform	**Android**	**React Native**	**Ionic**	**Cordova**
Application size	1,5 MB	7 MB	3,5 MB	2 MB
Start-up	~1 s	~1 s	~5 s	~2 s
Accuracy	~2 ms	~2 ms	~50-75 ms	~2ms
Operating systems	Android	Android, iOS, Windows	Android, iOS, Windows	Android, iOS, Windows
Language	Java	Java, JavaScript	JavaScript, HTML5	JavaScript, HTML5

The main decision was made between React Native and Cordova. While React Native's performance is supposedly much closer to native platform than with Cordova, which operates in a native WebView, there was the trade-off of React Native having its own syntax and idiosyncrasies that would have taken time to learn. However, on a simple application the performance difference was negligible and the development time with Cordova was expected to be much shorter. As a result, Cordova was chosen as the underlying framework.

Although there have been concerns of the accuracy of web-based reaction times and how they may be influenced by several factors such as variation of operating systems, CPU speed, and browsers and so on, it should be noted that Project Implicit itself is built with JavaScript. Numerous studies concerning reaction time accuracy in web-based experiments have been done. For example, JavaScript can be used to accurately detect reaction time differences with some caveats [16]. Variability of hardware and software can have a detrimental effect on accuracy but it can be partly compensated with a larger sample size, and web-based experiments can be an acceptable source of data that is comparable to a laboratory setting [17]. Hilbig [18] explains how numerous web-based studies have been able to replicate laboratory-based findings, but that skepticism still remains widespread. Hilbig's own experiment indicated that web-based findings were not in any way inferior to other methods.

4.2 Steps in Systems Development

After the framework selection, the next steps involved mock-ups and prototype development in order to produce a user interface that was both functional and had the right style for the purpose of the application. The style (look and feel) were guided by experiences with mobile games overall, as well as the objective of keeping the system light and simple. In addition the developer team drew on 10+ years of experience on mobile application design and UX assessment experience – making the process a combination of science, art and experience [13]. Layouts, color schemes and application views were designed by using mock-ups, evaluating the look and feel within the development team, and finally a prototype to iterate the designs. For example, where the original IAT test [15] is fairly serious and succinct as regards the test results, and in a gamified approach it was necessary to display a score and offer all content in a light and casual style. Developing the application itself involved two main segments: the IAT based core, and then gamifying the core. Where the original IAT test online [15] provided guidance for functional requirements for gathering the implicit measures needed in the system, the PSD analysis and the design principles filtered from that analysis provided further design requirements so that specific persuasive features could be implemented. For the backend SQLite was used as a database engine. The database was accessed with Cordova-sqlite-storage plugin. To provide more compatibility with AngularJS, database queries were run through a wrapper provided by ngCordova library. During a game session, data is stored in an AngularJS service. After each game session data is saved into an offline SQLite database.

Based on the requirements based both on the model from the IAT and PSD model, two game modes were implemented. In the first mode, the user would associate foods with two different words (a negative word and a positive word) displayed on left and right side of the screen. In the second mode, the same categorization would be performed the other way: instead of words, food icons would be placed on left and right side of the screen while the user would be shown different words, both positive and negative, on center of the screen.

User interface was constantly revised during the creation of both game modes. After it was tested that the game data was correctly being recorded, functions for saving the data into database were created.

4.3 Programming a Gamified System

When both required game mods were completed, the next step was to design a gamification system for them. The framework provided by Werbach and Hunter [13] was used as a basis for design. The relatively simple structure of the IAT framed and limited the analysis and selection of gaming elements. On the other hand, IAT also provided a foundation from which gamification could be implemented.

Typically, the IAT includes at least the following elements: two target concepts, an attribute, scoring and feedback. The general structure of the test is as follows: instructions, test, where images or word are shown and feedback (score is calculated in the background based on the responses). On its own, IAT does not contain a particularly large amount of content. For instance, in the test that measures racial bias, a total of 12 faces and 16 words are included. The test results are given in verbal form as follows: strong (implicit preference), moderate, slight and little to no difference. As such, in its design IAT does not necessarily encourage the user to retake the test multiple times since the content stays the same and the feedback is given in a relatively vague and non-transparent manner.

The first two steps in the gamification implementation process [13] concern business objectives and target behaviors. The underlying goal in the present system is to see whether a gamified test could be used to help people adopt healthier eating habits. In practical terms, in the context of this application the ideal scenario would be that the user would correctly categorize the given images and words as fast as possible and without any errors. With this and the self-reflection functionalities contained in the application, the implicit decision-making is expected to translate into corresponding behavior in the real world.

The third step in the process [13] is to describe the users, which is accomplished as part of the PSD analysis. The most relevant issue concerning gamification and different user groups was reaction time as it is a central feature in IAT. To make implementation more straightforward, it was decided that timing thresholds for what would constitute too fast, fast, normal and slow reactions would be gathered from existing research [3,19,20] rather than trying to implement a complex system where user's own performance would change timing thresholds between different game sessions.

In the fourth step [13], activity loops in the form of engagement loops and progression stairs are described. The IAT provides the central part of the loop where the user categorizes foods or words correctly. Feedback is provided by allowing the player to continue to the next image or word, or by presenting an error indicator. After the player has finished the session, results are presented. This loop was refined further by introducing the concept of unlockable content. The player starts with 10 available foods, five healthy and five unhealthy. Overall, the game contains 72 different foods. 34 healthy foods were selected as items that could be unlocked by playing the game. For each food, a short informative text describing health benefits was created. Unhealthy foods would also be unlocked in the background but no information on them would be provided to the user. The food selection (healthy vs. less healthy) was based on the principles presented in current governmental dietary recommendations[1], on the principle that lower fat and sugar content is to be favored over high fat or sugar content, among other things.

To provide a more concrete way to see progress, the concept of levels was introduced. By tying one unlockable food to each level, the game contains an elementary type of progression stairs. In earlier research, points had been identified as a key element in a gamified system. Points were also a suitable construct for this game to allow the tracking of user progress and to be able to differentiate between different levels. When the user's point total would exceed the required points to reach a new level, the informational text of the unlocked food would be displayed to the user.

In the end, the engagement loop would ideally work so that the player's initial motivation would be further encouraged by providing the player information about different foods. Additionally, the self-monitoring functionalities that would be implemented would also function as a form of feedback that would sustain or increase

[1] Finnish Food Safety Authority (EVIRA): Nutrition recommendations for all. https://www.evira.fi/en/foodstuff/healthy-diet/nutrition-recommendations-for-all/ (date of reference 15 March, 2018.

motivation. Almost all game components, including points and levels implemented in this game can be considered a form of feedback that affects motivation, which in turn causes actions, which provide feedback and so on [13].

The fifth step [13] deals with fun and making the system engaging. The structure of IAT by itself does not necessarily contain aspects that could make it fun. Due to this, whenever possible the text content of the application was written in a more casual and informal manner compared to the content found in the original IAT. Random appearances of different foods that granted bonus points were also added to provide a little bit of gameful atmosphere. Additionally, instead of using real food images, game-like icons were selected to portray the foods displayed to the user. Finally, as detailed in the previous paragraph, implementing progression stairs with its related points, levels and unlockable content should make the game more engaging compared to a normal implicit association test. Finally, in the sixth step [13] the actual elements and structures are deployed. Points, levels and content unlocking were selected as central gamification elements for this application.

The two chosen tasks, associating foods with words and words with foods, were not the same type of tasks that IAT uses to calculate the IAT effect, so an elementary scoring system had to be developed for the game. The reaction time, defined as the time between displaying an item and the user responding to it for the first time, was a straightforward choice on which the scoring would be based, and only correct responses would award points to discourage extremely quick responses.

For tasks similar to this game, the reaction time had varied from 500 milliseconds to 700 milliseconds [3]. In another implicit attitude measurement instrument, the Go/No-go Association task, 500 to 850 milliseconds is explained to be an appropriate range for measuring automatic attitudes [19]. In A 200 millisecond response time has been considered to be too fast to process and respond [20]. In [3] all responses below 300 milliseconds were recoded to 300 milliseconds before conducting any analyses. On the other end, all responses above 3 seconds were recoded to 3 seconds. Based on these values the lower limit for the scoring algorithm was set to 300 milliseconds and the upper limit to 2000 milliseconds to still award a small amount of points so as not to discourage players needlessly. However, the reaction times that were recorded still contained the original reaction times as only the point scoring part was done with recoded values.

With the goal of faster responses awarding more points, a simple formula of (1/(reaction time/100))^1.5*10 was created (where reaction time is in milliseconds, for example 552). At the same time when the scoring formula was developed, the different levels and their required points were also created. By testing the application prototype, a rough estimation of the length of one game session could be obtained. This allowed the testing of different types of reaction times to determine how long it would take for a user to reach a new level. In an exhaustive gamification project this step would have involved a larger scale testing with different users to find a perfect balance between different reaction times and the time needed to reach a new level. In the present project, the final values were mostly based on developer testing. To provide slight variability in progression, required points for each level were varied (see Table 5).

Table 5. An extract from the level structure

Level	Total score needed	Unlocked food	Level name
1	750	Chili	Chilin' along
2	1500	Fig	Figuring it out
3	2500	Banana	Going bananas
4	3500	Avocado	Playing devil's avocado
5	5000	Coconut	Go nuts

Database structure was revised further to add a new level table to contain level information. Other gamification related fields, such as a field for unlock texts, were also added to other tables when necessary. For scoring purposes, a scoring service was created. After this, the functions that handled storing the player and round information into the database were modified to include the handling of points. The logic for advancing from one level to another was also implemented.

4.4 Feedback and Background Content

To support self-reflection, the need for a feedback channel was identified in the PSD analysis. 'My profile' in the system consists of three views. The main view contains the overall status of the player, including current point total, high score and level. It also includes three different charts containing a line chart for points and reaction data and a bar chart for the amount of correct responses. In the main view, the user is also able to reset his/her gameplay data. As the application was planned to be used for research purposes [21], an option for sending data was built. It fetches all the available gameplay from the database and sends it to a server in a JSON format, where it is saved into a database and if needed, sent in a CSV format to a researcher.

Within the main view, links for additional statistics and a list of unlocked foods are provided. Statistics displays information about the Food Association gameplay mode and lists the percentage of correct responses and average points and reaction for each food. Finally, a longer version of game instructions was written for the About section and pages for other miscellaneous information, including icon and open source software licenses were created.

4.5 Application Structure in the Initial Release

Table 6 gives an overview of all the views and their related controllers in this application. Fig. 1 illustrates the basic UI hierarchy, and Table 7 lists the application's services and modules.

The basic structure of the application (Fig. 1) aims at quick access to gameplay without compromising the visibility of the remaining persuasive elements offering feedback on performance and providing credibility support. The start screen offers the same three basic options as the navigation bar at the bottom of the screen (always available to the user as shortcuts): play, look at profile page, and 'About' section. The primary task for the user is to play the game, and the path is to simply select Play, then pick of two modes (food association or word association), and play. To make repeated play easier, at the end of each game a 'quick play' option simply starts a new game in the same mode as selected before. This way player does not have to go to mode selection again until he or she wishes to change the mode.

Table 6. List of application's views and controllers

View (and controller in dynamic pages)	Description
Main menu	Screen displayed to the user when the application is launched.
Game mode selection	Allows the player to select from two game modes.
Game start	Start screen for the selected game mode. Shows instructions and items that are used in the game session.
Game screen	Gamified version of IAT where the user categorizes foods or words.
Game results	Displays game session results. Also shows progress towards next locked food. If needed, displays information on unlocked food if the user has reached a new level.
My Profile	Displays overall information about the user performance, including current level, high score, total points and charts for points, reaction times and correct responses. Provides functionalities for resetting the user profile and for sending research data.
My Profile - unlocked foods	Displays unlocked foods and allows the user to re-read food information.
My Profile - statistics	Provides statistics about the Food Association mode.
About (how to play, healthy eating, about this app)	Provides general instructions on the game and lists resources related to healthy eating. Additionally, shows information about the app such as the author and links for learning more about IAT. Open source licenses are also included.

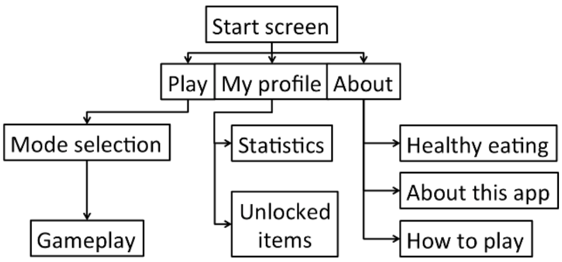

Fig 1. User interface hierarchy basic structure, showing core options a player has on any given path, starting from the Start screen at the top. The figure does not show every screen, such as instruction screens.

Table 7. List of application's services and modules

Name	Description
ImplicitFood module	Functions as a main module on which other modules are attached. Also contains definition for application's routing.
My Profile module	A container to which all profile related controllers are attached.
Play module	A container to which all gameplay related controllers and services are attached.
Database service	Provides functions for running database queries.
Player service	Manages user information. Responsible for updating scores and levels and for getting data from played sessions from the database.
Game services	Responsible for setting up the game session by getting data from the database and ensuring it is in needed form.
Scorer service	Calculates scores for single rounds and whole session.
Round service	Stores round data during game session and handles the saving of round data to database.

5 Discussion and Conclusion

The present paper discusses the development steps of a highly gamified BCSS, aiming at increasing its users' fruit and vegetable consumption. Some behavioral outcomes form gameplay are described in [21], where game data was combined with self-reported measures in order to evaluate the effectiveness of system features on the target behavior. The system was developed to use the IAT as a basis of implicit attitude feedback for reflection, using the PSD model to guide and determine the persuasive elements of the system.

From the process itself and the system developed it was possible to see that a two-tier approach, where the base system (IAT as a BCSS) was put together first and the gamification part was applied second, was a feasible way of ensuring that both the requirements of building a BCSS and gamifying in a structured manner, was possible. In addition, an important outcome in our view was that by treating the BCSS and the gamification as two entities, the basic structure of the application itself was possible to see in clear segments (background, profile, game) that all employed their own relevant persuasive system features.

The present iteration of the application did not include social support, which undoubtedly would open further avenues for features that would increase both the persuasiveness of as well as engagement in the system. Social support is, therefore, identified as a major further development and research path for the presented system.

The design of the game and its backend allows observing not only players' reaction times to all items ('healthy' and 'unhealthy' items) and scores, but also correct/incorrect responses. Such data will be at the center of analysis when planning the next iterations for the system. For example, preliminary observations show that players tend to favor correct responses over faster reactions. In such a situation player data will directly inform the developers about an important development need: to make the system more sensitive in measuring automatic reactions, it would be beneficial to encourage the players to really try to be as fast as possible and not to prioritize correct answers over speed. With a functional first release of the game available, and the game data that can be collected with it, it will be possible to execute design iterations that prioritize the most problematic issues first.

References

1. Oinas-Kukkonen, H.: A foundation for the study of behavior change support systems. Pers Ubiquit Comput 17(6):1223–1235 (2013).
2. Oinas-Kukkonen, H. and Harjumaa, M.: Persuasive systems design: key issues, process-model, and system features. Communications of the Association for Information Systems, 24 (2009).
3. Greenwald, A. G., McGhee, D. E., & Schwartz, J. L. Measuring individual differences in implicit cognition: the implicit association test. Journal of personality and social psychology, 74(6), 1464 (1998).
4. Greenwald, A.G., Poehlman, T.A., Uhlmann, E.L, & Banaji, M.R. Understanding and Using the Implicit Association Test: III. Meta-Analysis of Predictive Validity. Journal of Personality and Social Psychology, Vol 97, No. 1, 17-41 (2009).
5. Craeynest, M., Crombez, G., De Houwer, J., Deforche, B., Tanghe, A. & De Bourdeaudhuij, I. Explicit and implicit attitudes towards food and physical activity in childhood obesity. Behaviour Research and Therapy 43, 1111-1120 (2004).
6. Roefs, A., & Jansen, A. Implicit and explicit attitudes toward high-fat foods in obesity. Journal of Abnormal Psychology, 111(3), 517-521 (2002).
7. Maison, D., Greenwald, A.G. and Bruin, R.: The Implicit Association Test as a Measure of Implicit Consumer Attitudes. Polish Psychological Bulletin, 32, 1-9 (2001).
8. Richetin, J., Perugini, M., Prestwich, A., & O'Gorman, R. The IAT as a predictor of food choice: The case of fruits versus snacks. International Journal of Psychology, 42(3), 166-173 (2007).
9. Festinger, L. A theory of cognitive dissonance, Evanston, IL: Row & Peterson (1957).
10. Seaborn, K., & Fels, D. I. Gamification in theory and action: A survey. International Journal of Human-Computer Studies, 74, 14-31 (2015).
11. Deterding, S., Dixon, D., Khaled, R., & Nacke, L. From game design elements to gamefulness: defining gamification. In Proceedings of the 15th international academic MindTrek conference: Envisioning future media environments (pp. 9-15). ACM (2011).
12. Zichermann, G., & Cunningham, C. Gamification by design: Implementing game mechanics in web and mobile apps. O'Reilly Media, Inc. (2011).
13. Werbach, K., & Hunter, D. For the win: How game thinking can revolutionize your business. Wharton Digital Press (2012).
14. Mora, A., Riera, D., Gonzalez, C., & Arnedo-Moreno, J. A literature review of gamification design frameworks. In Games and virtual worlds for serious applications (VS-Games), 2015 7th international conference on (pp. 1-8). IEEE (2015).
15. Project Implicit. https://implicit.harvard.edu/implicit/takeatest.html (2011).

16. Reimers, S., & Stewart, N. Presentation and response timing accuracy in Adobe Flash and HTML5/JavaScript Web experiments. Behavior research methods, 47(2), 309-327 (2015).
17. Chetverikov, A., & Upravitelev, P. Online versus offline: the Web as a medium for response time data collection. Behavior research methods, 48(3), 1086-1099 (2016).
18. Hilbig, B. E. Reaction time effects in lab-versus Web-based research: Experimental evidence. Behavior research methods, 48(4), 1718-1724 (2016).
19. Nosek, B. A., & Banaji, M. R. The go/no-go association task. Social cognition, 19(6), 625-666 (2001).
20. Nosek, B. A., Bar-Anan, Y., Sriram, N., Axt, J., & Greenwald, A. G. Understanding and using the brief implicit association test: recommended scoring procedures. PLoS One, 9(12), e110938 (2014).
21. Tikka,P., Laitinen, M., Manninen, I. & Oinas-Kukkonen, H. Reflection through Gaming: Reinforcing health message response through gamified rehearsal. Proceedings of Persuasive Technology (2018).