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Improving The Efficacy Of Games for Change Using Personalization Models

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There has been a continuous increase in the design and application of computer games for purposes other than entertainment in recent years. Serious games—games that motivate behaviour and retain attention in serious contexts — can change the attitudes, behaviours, and habits of players. These games for change have been shown to motivate behaviour change, persuade people, and promote learning using various persuasive strategies. However, persuasive strategies that motivate one player may demotivate another. In this article, we show the importance of tailoring games for change in the context of a game designed to improve healthy eating habits. We tailored a custom-designed game by adapting only the persuasive strategies employed; the game mechanics themselves did not vary. Tailoring the game design to players' personality type improved the effectiveness of the games in promoting positive attitudes, intention to change behaviour, and self-efficacy. Furthermore, we show that the benefits of tailoring the game intervention are not explained by the improved player experience, but directly by the choice of persuasive strategy employed. Designers and researchers of games for change can use our results to improve the efficacy of their game-based interventions.

CCS Concepts: • **Human-centered computing→Empirical studies in HCI** • Human-centered computing→HCI theory, concepts and models • **Applied computing**→Computer games • Software and its engineering→Interactive games • *Social and professional topics→User characteristics.*

Additional Key Words and Phrases: Serious games, persuasive games, games for change, gamer types, player types, personalization, tailoring, health intervention, tailored persuasion, persuasive strategies, persuasive technology, healthy eating

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1. INTRODUCTION

People often find it difficult to motivate themselves to perform activities that are beneficial, such as exercising, eating well, or practicing to learn a skill. In contrast, digital games are known to motivate players for hours at a time and encourage play that culminates in completion of a game [Ryan et al. 2006]. This increasing adoption and integration of games into daily life presents

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unique opportunities to use games to positively affect our world. As a result, the recent years have witnessed a continuous increase in the design and application of computer games for purposes other than entertainment. Research has demonstrated that games can be strategically designed to motivate desirable behaviour change, for example, to help people overcome addictive behaviours such as substance abuse [King and Tester 1999], promote personal wellness and engage in preventive behaviours [Grimes et al. 2010; Consolvo et al. 2009; Orji et al. 2013; DeSmet et al. 2014], avoid risky sexual behaviour [Jemmott et al. 1992; Duncan et al. 2014] and manage chronic diseases [Brownson and Kumanyika 2007; Lieberman 2001]. This research has led to an increasing interest in the design, development, and understanding of serious games – that is, games that motivate behaviour and retain attention in serious contexts. Serious games have been applied as digital interventions in many domains including smoking cessation [Khaled et al. 2008], energy conservation [Bang et al. 2006], healthy eating [Orji et al. 2012; Orji 2014], and physical activity [Berkovsky et al. 2010], and have been shown, for example, to motivate behaviour and attitude change [Stokes 2005; Baranowski et al. 2008; Gerling et al. 2014] , persuade people [Bogost 2007; Fogg 2003], and promote learning [Kiili 2005], and are often referred to as *games for change*.

Despite this growing interest and investment into games for change and gamified systems, current games for change suffer a major limitation: most games for change adopt a "one-size-fits-all" approach to their design. However, recent research shows that this approach may not be effective because different types of people are motivated by different persuasive strategies [Orji et al. 2013], and a strategy that worked well with one group of people may demotivate a different group [Orji et al. 2013; Kaptein et al. 2012]. Consequently, there is an increasing demand for persuasive games – especially those addressing health behaviours – to be tailored to the target users' motivation [Khaled 2008; Berkovsky et al. 2010]. Although a few games for change have been designed with a specific group in mind (e.g.,[Khaled et al. 2008]), researchers have only started to model how groups of people respond to the differing strategies used in games for change [Orji et al. 2013; Orji et al. 2014], and there is little existing knowledge to guide serious game designers who wish to tailor their games for maximum efficacy.

To determine whether personalization is necessary in the context of serious games for health and to guide the resulting design of games for change, we developed models showing how people from seven gamer types [Nacke et al. 2013] respond to eight commonly-employed persuasive strategies [Orji et al. 2014]. We then used the model to design a tailored and a contra-tailored version of a persuasive game for two common gamer types (Achievers and Conquerors) using two common persuasive strategies (Reward and Competition/Comparison). The results of a large-scale randomized controlled study of 335 Achievers and Conquerors (272 valid participants) showed that tailoring a persuasive game increased its effectiveness with respect to promoting desired changes in attitudes and intentions that lead to healthy behavior while contra-tailoring did not. Specifically, the results show that if we fail to consider gamer type, neither persuasive strategy emerges as being more effective than the other; however, considering gamer type reveals that players only respond to the tailored persuasive game intervention (Reward for Achievers and Comparison for Conquerors) and not to the contra-tailored intervention, even though the underlying game mechanics were the same in both interventions. In addition, parallel mediated regressions [Hayes 2013] show that the beneficial effects of tailoring are not explained by the improved player experience that results from a personalized game that appeals more to that gamer type. Our research is relevant for researchers who investigate games as interventions in domains such as health. In addition, as the use of games as digital interventions continues to increase, our results on the necessity of personalization are important to help guide the design decisions of game designers and developers.

Our research has four main contributions as follows: First, we show the importance of tailoring games for change by demonstrating in a controlled large-scale experiment that tailoring a serious game's design to a player's personality type improved the game's effectiveness, as measured by change in attitude, self-efficacy, and intention. Second, a major drawback to tailoring persuasive game interventions is the cost – there is work involved in designing/adapting persuasive games. We show that games for change can be tailored by adapting only the persuasive strategies employed in the game design, and not the game's mechanics, themes, or narrative. Third, we show that the benefits of tailoring the game-based intervention are not mediated by the improved player experience that results from the game appealing to the gamer type, but are explained directly by the choice of persuasive strategy employed. Fourth, we show that persuasive game designed using a single appropriate strategy can be effective, therefore, game developers and designers of games for change do not have to employ multiple strategies to make their games effective.

2. BACKGROUND AND RELATED WORK

The design and use of games for serious purposes (purposes other than entertainment) has attracted the attention of both researchers and practitioners in the area of Human-Computer Interaction (HCI). Studies have shown that games can be an effective approach for behavior change in an intended manner [Fujiki et al. 2008; Orji et al. 2012]. As a result, HCI researchers have designed and applied games as digital interventions in many domains including smoking cessation [Khaled et al. 2008], energy conservation [Bang et al. 2006], healthy eating [Orji et al. 2012; Orji 2014; Alamri et al. 2014], and physical activity [Berkovsky et al. 2010; Fujiki et al. 2008]. Among all the domains of applications of serious games, the use of serious games for health promotion and disease prevention/management have received special attention, likely due to the importance of maintaining good health and wellness. Therefore, this review will focus mainly on serious games for health.

Various terminologies and definitions have been given to games designed for purposes other than entertainment. For instance, the term "serious games for health" has been used to define games that are designed to entertain, educate, and train players, while attempting to modify some aspect of the player's health behavior [Stokes 2005]. Bogost used the term "persuasive game" to describe video games that mount procedural rhetoric effectively [Bogost 2007]. However, the term "serious game" and "persuasive game" are often used interchangeably in the literature, referring to games that are designed with the primary purpose of changing a user's behavior or attitude using various persuasive strategies [Fogg 2003; Orji et al. 2013; Khaled et al. 2009].These games have also been called games for change (see gamesforchange.org). Therefore, we adopt this as the working definition in this paper and will use the term "persuasive game" or "game for change" throughout, to differentiate our work from other types of serious games, e.g., games for learning.

In this section, we present a brief overview of persuasive strategies that are often employed in the design of games for change. This is followed by a review of persuasive game interventions and the various strategies that are employed. We conclude by summarizing research efforts toward tailoring games for health.

2.1 Persuasive Strategies

A fundamental feature of games for change is the use of persuasion, i.e., an attempt to influence or reinforce behaviors, attitudes, feelings, or thoughts [Khaled et al. 2009]. Persuasion is achieved using various strategies, which are techniques that can be employed in games for change to promote desirable behaviours or attitudes. Over the years, a number of persuasive strategies have been developed. For example, [Fogg 2003] developed seven persuasive tools, and [Oinas-kukkonen and Harjumaa 2008] built on Fogg's strategies to develop 28 persuasive system design principles.

A recent study identified Competition, Simulation, Self-monitoring and Feedback, Suggestion, Customization, Praise, Reward, Comparison, Cooperation, and Personalization, as 10 commonly-employed strategies in the design of games for change [Orji et al. 2014].

- **Competition** strategy allows users to compete with each other to perform the desired behavior.
- **Simulation** provides the means for a user to observe the cause-and-effect linkage of their behavior.
- **Self-monitoring** (also called Feedback) allows people to track their own behaviors, providing information on both past and current states.
- **Suggestion** strategy suggests certain tasks (for achieving favorable behavioural outcomes) to users during system use.
- **Customization** is a strategy that provides the user an opportunity to adapt a system's contents and functionality to their needs or choices.
- **Praise** applauds the user for performing the target behavior via words, images, symbols, or sounds as a way to give positive feedback to the user.
- **Reward** offers virtual rewards to users for performing the target behavior.
- **Comparison** provides a means for the user to view and compare his/her performance with the performance of other user(s).
- **Cooperation** requires users to cooperate (work together) to achieve a shared objective and rewards them for achieving their goals collectively.
- **Personalization** offers system-tailored content and services to its users, based on a user's characteristics [Orji et al. 2014].

For a detailed discussion of the strategies, see [Oinas-kukkonen and Harjumaa 2008].

2.2 Games for Change and Human Computer Interaction

Games for change can be considered as effective if they successfully educate users about certain topics, facilitate desired behavior or attitude change, or raise awareness [Busch et al. 2015]. Games for change have been applied in many domains including education, sustainability, and health. Within the health domain, several games for change have been developed employing one or more of the persuasive strategies described above to achieve their intended objectives of either health promotion or disease management [Orji et al. 2013; Shegog 2010].

For example, *National Mindless Eating Challenge* (NMEC) is a mobile phone-based health game aimed at promoting healthy eating behavior [Kaipainen et al. 2012]. NMEC employs the *Reward, Comparison, Customization, Suggestion,* and *Personalization* strategies. NMEC players are tasked with caring for a virtual pet or plant and this requires them to follow a variety of healthy eating recommendations. At the beginning of the game, the player selects an initial eating goal and sub-goal and based on their chosen goals, players are assigned tasks that are relevant to their eating goals – *Personalization.* The game also allows players the flexibility to enable and disable various game features – *Customization.* At the end of each month, players are evaluated and given new suggestions on how to reach their goals in the subsequent month – *Suggestion.* Players also receive *Reward*s and compare their performance with the performance of others – *Comparison.* Similarly, *LunchTime* is a slow-casual game for motivating healthy eating [Orji et al. 2012]. *LunchTime* employs the *Reward, Competition,* and *Comparison* strategies. Players play the role of a restaurant visitor, and the goal is to choose the healthiest option from a list of food choices. Players are awarded points – *Reward* – and each player is allowed to view and compare their performance with that of other players – *Competition* and *Comparison.*

RightWay Café is a role playing game that employs *Customization, Competition, Simulation, Personalization,* and *Suggestion* to promote healthy eating and physical activity [Peng 2009]. At the beginning of the game, the players create a representative avatar using their own personal information, such as name, weight, height, age, gender, physical activity, and body frame – *Customization.* Using the specified attributes of the avatar, the game provides *Personalized* healthy eating and *Suggestions* with regard to optimal weight and daily calorie consumption. A player is tasked with the role of managing the avatar's daily calorie consumption and physical activity to enable it to reach optimal weight. The player who best managed the avatar's daily diet in a healthy way wins the game – *Competition.* At the end of each week the game simulates the weight change based on the foods the player chooses – *Simulation.*

Typical examples of persuasive games in the area of physical activity are Neat-o-Games [Fujiki et al. 2008] and Fish 'n' Step [Lin et al. 2006]. Neat-o-Games is a game for change that employed *Competition, Comparison, Reward,* and *Self-monitoring* to promote physical activity. The virtual racing game requires players to race with other players over their mobile network. A player's physical activity (monitored using wearable accelerometers) is used to control the speed of the player's avatar in the racing game – Self-monitoring. Players are awarded activity points – *Rewards.* At the end of every day their activity points are compared and winners are announced - *Competition and Comparison.* Similarly, Fish 'n' Step, employs *Competition, Cooperation, Reward,* and *Self-monitoring and Feedback* in a game to promote physical activity. A player's step count is linked to the growth and activity of a virtual fish in a tank. A player's fish tank includes other players' fish, thereby fostering both *Cooperation* and *Competition.* Players could compete as an individual or as part of a team (*Cooperation*) and are provided feedback regarding their progress, burned calories, personal, and team ranking. At the end, players are rewarded for achieving their daily step count goals by changing the appearance, number, and size of their fish.

Finally, another successful application of *Reward, Simulation, Cooperation,* and *Praise* can be seen in the strategies implemented in a smoking cessation game called Smoke? [Khaled et al. 2008]. Smoke? is a narrative game that *Simulates* six weeks of the life of a virtual character called MC. The player controls MC's life by deciding the course of action to increase MC's chances of quitting successfully. By so doing, players learn how to overcome perceived barriers associated with quitting smoking. Players are also given the opportunity to convince a friend to quit smoking – *Cooperation.* At the end of the game, players observe the benefits associated with their decisions and how their decisions boost MC's mental well-being – *Reward.*

Games for change have also been used to help patients improve their health-related self-management skills – e.g., disease management. For example, *Packy and Marlon* is an adventure game that helps children and teenagers self-manage their type 1 diabetes. The player's goal is to keep their characters' diabetes under control by monitoring blood sugar, providing insulin, and managing food and other related illnesses [Brownson and Kumanyika 2007]. Packy and Marlon is modeled against diabetes challenges. To win, each of the two players – Packy and Marlon – have to successfully manage their insulin and food intake; therefore, they must support each other – *Cooperation.* At the beginning of the game, players can set their desired insulin option, fix dose – *Customization*, and monitor the fluctuation in blood glucose in response to their behavior choices in the game – *Self-monitoring* and *Simulation.* Another example of a game for change in the health domain is GlucoBoy [Slater 2005] – a game for diabetes self-management. Similarly, *Bronki the Bronchiasaurus* is a role-playing adventure game aimed at imparting asthma management skills on young children with asthma [Lieberman 2001]. The game impacts skills for self-monitoring and simulates good and bad real-world asthma self-management skills. The game presents two animated characters (Bronkie and Trakie), and tasks players with helping the in-game characters keep their asthma at bay by avoiding triggers such as dust and smoke while they go on their quest, measuring and monitoring breath strength – *Self-monitoring*, taking medications as needed, and using the inhaler correctly. The character's health outcome is dependent on the player's health decision in the game – *Simulation* – and a good health outcome is needed to win the game – *Competition.* This review of games for change in the domain of health is by no means exhaustive, but does provide a good representation of the common practices in the application of persuasive strategies in games for changing health behaviour.

From the review, Competition and Reward emerged as two frequently employed strategies [Bell et al. 2006; Grimes et al. 2010; Orji et al. 2012] – almost all existing games employed one form of Competition and Reward.

2.3 Tailoring Games for Change

Most existing games for change take a one-size-fits-all approach, rather than tailoring their content and strategies to individual users or user groups. Several researchers have pointed to the limitations and risks of the *one-size-fits-all* approach to game-based intervention design, especially when aimed at motivating health behavior [Khaled et al. 2008; Berkovsky et al. 2010]. However, a few games for change have been designed with a specific user or cultural group in mind. For example, [Khaled et al. 2008] investigated the feasibility of tailoring a game for change based on an individual's cultural background in a game called *Smoke?*. To tailor the game to various cultural groups, the authors developed two versions of the game (one for the collectivist and one for the individualist culture) using strategies that are deemed appropriate for each group. The result of the evaluations showed that individualist players were persuaded more by the individualist version of the game than when playing the collectivist version. Another example of tailored persuasive games can be seen in the design of a physical activity motivating game called *PLAY, MATE!* [Berkovsky et al. 2010]. To minimize the variability in the perceived enjoyment and amount of activities performed by novice and experienced players, PLAY MATE! tailored the rewards and personalized the difficulty level by adjusting the reward times for novice and experienced players. The tailoring balanced the number of activities performed by novice and experienced players without affecting the perceived enjoyment. PLAY MATE! tailored the strategies by varying the time required to complete a task between novice and experienced players; however, the same strategy – *Reward* – still applied to every player. For detailed review of persuasive health interventions and strategies employed see [Orji and Moffatt 2016].

In these few initial examples of investigating how games for change can be tailored to increase their effectiveness, the choice of persuasive strategy employed has not been a source of tailoring. Similarly, the influence of various gamer personalities (gamer types) and player models (e.g. [Nacke et al. 2013; Bartle 1996; Houlette 2003]) on persuasive game efficacy have largely been ignored. However, decades of research on gameplay motivation has shown that treating gamers as a monolithic group is a bad design approach [Bartle 1996; Bateman and Nacke 2010; Yee et al. 2012] – as what works for one individual may actually demotivate another [Orji et al. 2013]. Therefore, members of one gamer type may respond differently to various motivational strategies and applications, and games for change will be more effective when they are strategically appropriate for the gamer type under consideration.

3. RESEARCH QUESTIONS

With this research, we seek to enrich the HCI and games for change research communities by broadening existing knowledge and empirical evidence about the effectiveness of games for change and how they can be designed to increase their effectiveness. Specifically, we explore the hypothesis *that tailoring persuasive strategies employed in games for change to player type increases their effectiveness at motivating desired behaviour change.* To drive current literature even further we investigate whether the effect of tailoring is mediated by play experience. To explore the research hypothesis, we address the following specific questions:
RQ1: Does tailoring games for change to player type increase their persuasiveness?
RQ2: Are the beneficial effects of tailoring mediated by an improved play experience?

4. DEVELOPING PERSONALIZATION MODELS

In an initial study [Orji et al. 2014] with 1108 participants, we gathered data on how seven different gamer types as defined by the BrainHex model [Nacke et al. 2013]– *Achiever, Conqueror, Daredevil, Mastermind, Seeker, Socializer, and Survivor* – respond to ten different persuasive strategies that are commonly employed in the design of games for change – *Customization, Simulation, Self-monitoring, Suggestion, Personalization, Praise, Reward, Comparison, Competition, and Cooperation* [Orji et al. 2014]. Using storyboards showing a character interacting with a game for promoting healthy eating – which were designed according to established guidelines [Truong et al. 2006] – we asked our participants to respond to a series of questions related to how likely the ten persuasive strategies (depicted through ten different storyboards [Orji et al. 2014]) would influence their eating decisions. Participant feedback was gathered using a validated scale for measuring perceived persuasiveness [Drozd et al. 2012]. In addition, we also asked participants to complete the BrainHex questionnaire [Nacke et al. 2013] to determine their gamer type.

After validating that our storyboards depicted the intended strategy [Orji et al. 2014] and that the data were suitable to conduct factor analysis [Kaiser 1960], we performed Exploratory Factor Analysis [Costello and Osborne 1994], which revealed that participants were responding to eight unique strategies (Competition and Comparison loaded into one factor as did Self-monitoring and Suggestion) thereby reducing the number of strategies from ten to eight. We then employed Partial Least Square Structural Equation Modeling (PLS-SEM) to create models showing the efficacy of the eight persuasive strategies for each of the seven gamer types. Finally, we used the pairwise comparison approach [Chin 2000] to establish that the models differed across gamer types. See [Orji et al. 2014] for full details.

The results showed that the different gamer types are clearly motivated by different strategies and allowed us to create a structural equation model of the strength of motivation of different players that result from different strategies (see Table 1). A significant positive β value represents that a gamer type is motivated by that strategy; a negative β value represents that a gamer type is demotivated by that strategy; no β value represents that a gamer type is neither motivated nor demotivated by a particular strategy. For example, we found that Socializers are motivated by Cooperation; Achievers are motivated by Reward and Cooperation, whereas Conquerors are motivated by Competition and Simulation. Daredevils are demotivated by Self-monitoring/Suggestion, whereas Masterminds are neither motivated nor demotivated by Praise, Reward, or Cooperation, but are motivated by all other strategies. The intention of our work was to allow game designers and games for change researchers to use the results of our model to guide their design choices. For example, consider an online social game designed to motivate behaviour change. Because a large proportion of social gamers are Socializers, our model suggests that this type of game should use Cooperation, but avoid Praise or Suggestion. However, more importantly, our results suggest that gamer type must be taken into consideration when evaluating the efficacy of games for change. For example, consider an intervention designed to help players quit smoking that employs Rewards. If the majority of participants in a trial are motivated by Rewards – i.e., are Achievers, which is not an unreasonable assumption if using a sample of undergraduate students at a university – the researchers may assume that the intervention will be successful in the general population. However, our model suggests that the intervention will not succeed for the other six gamer types.

Table I. Beta Values from the SEM Process

Strategies / Gamer type	CMPT/ CMPR	COOP	CUST	PERS	PRAS	SEMT/ SUGG	SIML	REWD
Achiever	-	.15	-	-	-	.10	-	.10
Conqueror	.25	-	-	.12	-	.12	.14	-
Daredevil	-.10	-	-	-	-	-.14	.11	-
Mastermind	.12	-	.10	.12	-	.14	.12	-
Seeker	.10	-	.19	.11	.10	-	-	-
Socializer	.11	.17	-.12	-	-.12	-.13	-	-
Survivor	.17	-.20	-.13	-	-	.27	-	-.14

CMPT/CMPR = competition and comparison, COOP = cooperation, CUST = customization, PERS = personalization, PRAS = praise, SEMT/SUGG = self-monitoring and suggestion, SIML = simulation, REWD = reward.

5. EXPERIMENTAL VALIDATION

In this section, we present the design and evaluation of a game for change that uses the personalized models we presented in Section 4.

5.1 Model-driven Persuasive Game Design

To validate the results of our model in an experiment, and to determine whether or not we could use it in a prescriptive manner to inform the design of games for change, we designed and implemented a model-driven game for change intended to promote healthy eating, see Figure 1. Our game was based on the familiar casual game Space Invaders [Invaders 2014] and portrayed the conflict between healthy and unhealthy eating choices. Called JunkFood Aliens, our game represented healthy foods with fruits and vegetables and unhealthy foods with typical 'junk' foods, such as cupcakes, pizza, and ice cream. JunkFood Aliens was implemented using HTML5 and JavaScript and could be accessed using any internet-enabled device. Players assumed the role of a healthy eating hero on a mission to search for fruits and vegetables and save the planet from the invasion of junk foods. The players tried to consume healthy foods by shooting them using the avatar; however, to survive they had to gain strength by collecting the hearts (nutrients and vitamins) dropped by the healthy foods, and to eliminate the unhealthy foods that shoot bullets (fat, sugar and salt) and progressively advance down the screen (Figure 1). Occasionally a Superfood appeared, represented as a salad tray, that provided an extra life to the player when shot. Players played rounds progressing through levels with increasing difficulty with each round ending either when the players lost all their six lives, or when the JunkFood aliens reached the bottom of the screen.

We chose a simple game design with intention - by reducing the persuasive rhetoric of the game to a simple "veggies and fruits are good, whereas junk food is bad" narrative, we reduced potential interactions between the persuasive rhetoric and narrative of the game and the persuasion of the strategies employed.

Our model suggested that players of different types would respond differently to interventions that use different persuasive strategies. Specifically, our results proposed that Conquerors – i.e., challenge-oriented players who enjoy struggling against impossibly difficult foes before eventually beating other players [Nacke et al. 2013] – respond to Competition and Comparison, but not to Reward, whereas Achievers – i.e., goal-oriented players who are motivated by working towards the completion of long-term goals [Nacke et al. 2013] – respond to Reward, but not Competition and Comparison. To validate this prediction and study the influence of tailored game-based interventions to different gamer types, we developed two versions of JunkFood Aliens – one that used Reward as a persuasive strategy, and one that used Comparison & Competition. Reward, Competition and Comparison are the most frequently employed strategies by game developers and they can be easily mapped to two commonly used games mechanics: points, levels and badges (Reward) and leaderboards (Comparison and Competition).

In the Reward version (called "JunkFood Aliens-R"), we displayed the current point score and awarded players badges in recognition of their in-game achievements. There were five badges that could be earned in the game – Fan, Captain, Legend, King, and Hero, as shown in Figure 2. We employed a logarithmic Reward structure, which allowed players to earn badges quickly initially, but required more work as the player advanced in the game. To incentivize players, we showed locked badges and highlighted them as they were earned. The names of the badges, the total score and level required to unlock each badge, the total number of badges earnable, and the highest badge that could be achieved in the game were made visible to the player in the intervention page as shown in Figure 2. Once a player earned a badge, it appeared on the left side of the game panel.

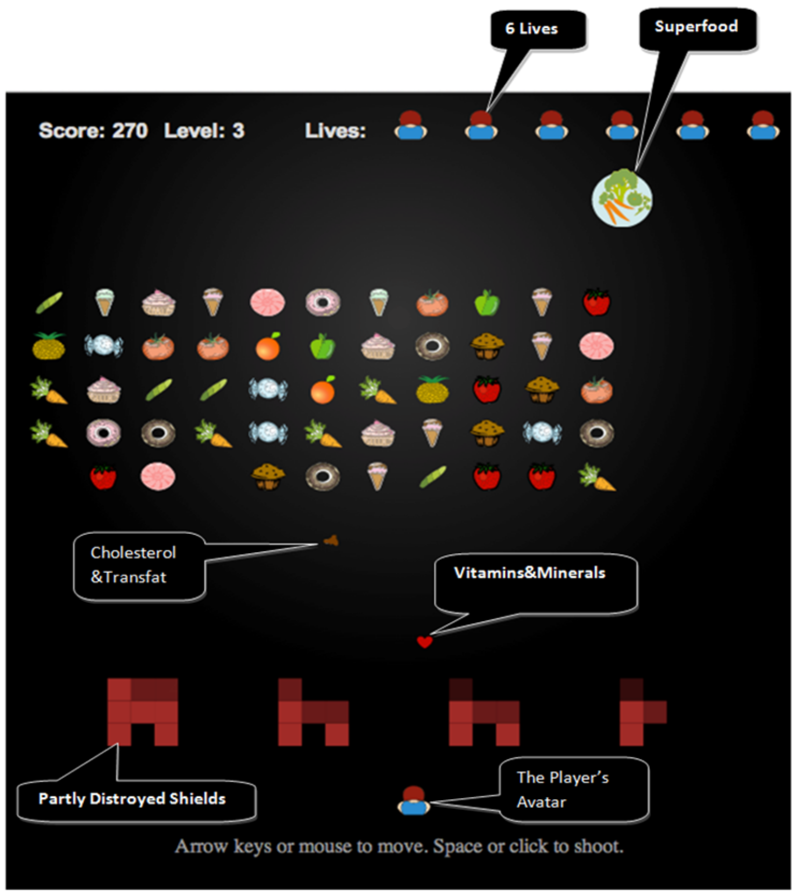


Fig. 1. Space-invaders themed game for change.

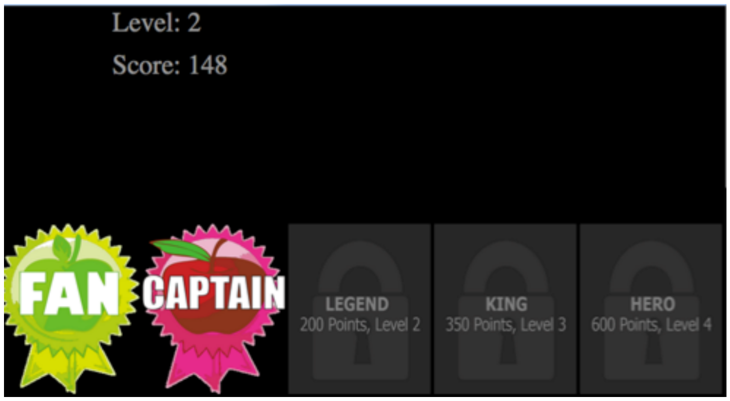
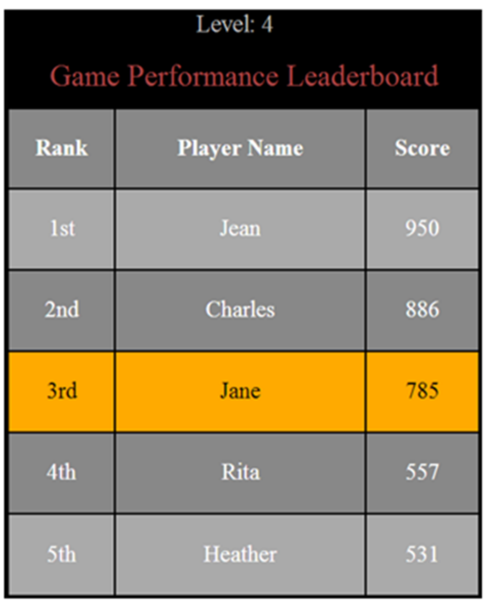


Fig. 2. Reward-based intervention.

In the Competition version of the game (called "JunkFood Aliens-C") we added a simulated leaderboard [Orji 2014; Bowey et al. 2015] that compared the performance of five players (the actual player and four imaginary ones) and displayed each player's name, score, and rank (see Figure 3). To simulate the leaderboard, we generated scores for the other players using an algorithm that created reasonable comparison scores, using the real player's score as a reference [Orji 2014]. For easy visibility, the player's position was highlighted using an orange background (see Figure 2). Note that the player maintained his or her actual score (i.e., not a simulated score), while the simulated competitors' scores were simulated in a position relative to the player.


Level: 4

Game Performance Leaderboard

Rank	Player Name	Score
1st	Jean	950
2nd	Charles	886
3rd	Jane	785
4th	Rita	557
5th	Heather	531

Fig. 3. Comparison-based intervention.

5.2 Model-driven Persuasive Game Evaluation

To investigate the influence of tailoring on the persuasiveness of a game for change, we conducted a large-scale evaluation of our two game versions (JunkFood Aliens-R and JunkFood Aliens-C) on two distinct gamer types – Achievers and Conquerors. We chose Achievers and Conquerors for two main reasons: first, they are the most common gamer types; identified by most existing player typologies (for example see, [Bartle 1996; Nacke et al., 2013]). BrainHex's Achiever corresponds to the Bartle's Achiever, and BrainHex's Conqueror corresponds to the Bartle's Killer. Second, Achievers and Conquerors show distinct perceptions of most of the strategies in our models, (see Table 1); making them interesting gamer types to explore further.

5.2.1 Study Design

The study was conducted online and it took an average of one hour for each participant to complete. To evaluate the effectiveness and impact of the two versions of JunkFood Aliens, we hosted the games on a University server and participants accessed the game through a link to the URL embedded in the study script.

Our experiment used a 2 (Gamer type: Achiever, Conqueror) by 2 (Intervention Type: Reward, Comparison) between-subjects design. After providing informed consent, participants completed the BrainHex survey (28 items) [Nacke et al. 2013], a demographic survey, and three scales based on the theory of planned behaviour [Ajzen 2006] to assess attitude toward healthy eating (7 items), healthy eating intention (7 items), and self-efficacy towards healthy eating (5 items). All scales demonstrated internal consistency, with Cronbach's alpha values above 0.70. Participants were then randomly assigned to one of the two intervention types. They then played the game for 20 minutes, during which the intervention was displayed each minute (Reward or Competition/Comparison), they recorded and submitted their score (to ensure that they paid attention). Following gameplay, participants completed the same scales assessing healthy eating attitude, self-efficacy, and intention and also assessed game play experience using the intrinsic motivation inventory (14 items) – a validated scale for measuring enjoyment, invested effort, perceived competence, and tension [Ryan et al. 2006]**.** For each participant, we obtained two mean values for their attitude, self-efficacy, and intention: one representing their baseline value and the other representing their post-intervention attitude towards healthy eating.

Although all players experienced playing the same game for change (JunkFood Aliens), we interrupted players each minute with either a Reward-based or Comparison-based persuasive intervention. The interventions were displayed to players each minute during game play until they were dismissed by player and the player had to write down the information presented during the intervention, to make sure that they paid attention to it. In the game version with the Reward-based intervention, the current point score, level and awarded badges in recognition of in-game achievements were displayed (Figure 2). In the game version with the Comparison-based intervention, the manipulated leaderboard (the actual player and four simulated ones) displayed each player's name, score, and rank (Figure 3).

To complete the game play section, participants had to record at least 20 different scores, ranks, levels, and badges displayed on 20 different appearances of the intervention page. The game was played continuously – participants decided when to exit from the game – but it restarted from level one each time a participant lost the game. This allowed participants to play the game as long as was required. After the participants completed playing the game, they were redirected back to the survey page where they completed the exit survey and submitted their recorded game performance scores. At the end of the study, each participant was given a unique code to indicate that they successfully completed the study and to receive their compensation.

Two pilot studies were conducted before the main study. The first (N=40) tested the validity of the study instrument. After some restructuring, a second pilot study (N=4) was conducted. The participants were observed while they played the game and completed the survey using a think-aloud approach. The second pilot study confirmed the suitability and understandability of the study instrument.

5.2.2 Data Collection and Filtering

All participants were recruited online through a crowd-sourcing platform (Amazon's Mechanical Turk (AMT)). We followed the recommendations for performing effective studies on AMT by Mason and Suri [Mason and Suri 2012], including the following:

- Used captcha and some open-ended questions that require some degree of intelligence and concentration.
- Ensured that participants could respond to the study only once, using a mechanism provided by AMT to collect responses from unique participants. The participants' identifications provided by AMT, were examined, which further ensured that no duplicate responses were received.
- Included time stamps and tracked the total time taken by participants to complete the study.
- Added attention questions to ensure that participants were actively considering their answers. Responses from participants who answered the attention questions incorrectly were discarded.
- Required participants to track and record their game performance at least for the first 20 minutes of play to ensure that they actively played the game for the required minimum duration and paid attention to the intervention pages.

We used AMT to allow us to access a large and diverse sample of participants. AMT ensured a diverse participants group from 32 different countries and five continents (Africa, Asia, Europe, North America, and South America). Moreover, AMT has been shown in previous work to be a valid tool for conducting user studies[Kittur et al. 2008], behavioural research[Crump et al. 2013; Mason and Suri 2012], games research[Orji et al. 2017; Orji et al. 2014; Birk, Atkins, et al. 2016; Depping and Mandryk 2017], and research in the context of health[Gillan and Daw 2016; Shapiro et al. 2013; Bowey et al. 2015; Mandryk and Birk 2017], however, we address some of the limitations of using crowdsourced data collection in our discussion of results.

5.2.3 Study Participants

A total of 901 responses was collected; from these, 335 responses were retained, mostly due to removing the large number of participants who were gamer types other than Achiever or Conqueror. We also removed the participants who did not correctly answer the attention-determining questions [Mason and Suri 2012]. The participants were at least 18 years of age and they were all computer or video game players, which ensured accurate classification and mapping to the gamer types. After randomly under-sampling to equalize the group distribution and gender balance, a total of 272 responses were included in this analysis; 117 of our participants were female and 155 participants were male; 136 of our participants were of Achiever type and 136 were of Conqueror type. The participants received compensation ($2 USD) for participating in the study.

6. DATA ANALYSIS

The main goal of this evaluation was to examine and compare the persuasiveness of the tailored game for change and the contra-tailored game for change with respect to their ability to promote changes in healthy eating attitude, self-efficacy, and intention. As a secondary objective, we also investigated if play experience mediated the effect of tailoring on the efficacy of persuasive games. To achieve this, we used several well-known analytical tools and procedures:

- First, we examined the scales for internal consistency using reliability analysis. Given the positive results, the data was found suitable to proceed with analysis.

- Next, after validating the data for the assumptions of ANOVA, we conducted a Repeated-Measures Multivariate Analysis of Variance (RM-MANOVA) with time (baseline, post-play) as a within-subjects factor and gamer type (Achiever, Conqueror) and Intervention Type (Competition, Reward) as between-subjects factors on attitude, intention, and self-efficacy toward healthy eating.
- Following findings of significant effects, we performed a planned pairwise comparison, using the Bonferroni method for adjusting the degrees of freedom for multiple comparisons, to determine the groups that significantly differ from each other.
- To determine whether the efficacy of the persuasive games was mediated by player experience, we conducted parallel mediation regression models of tailoring (tailored, contra-tailored) on attitude change, intention change, and self-efficacy change, with experienced enjoyment, invested effort, perceived competence, and tension as mediators and while controlling for gender.

7. RESULTS

The analysis showed that all the scales demonstrated internal consistency, with Cronbach's alpha values above 0.70.

Gamer Type. The results of the RM-MANOVA with time (baseline, post-play) as a within-subjects factor and gamer type (Achievers, Conquerors) and Intervention Type (Competition, Reward) as between-subjects' factors on attitude, intention, and self-efficacy toward healthy eating show that there was no main effect of gamer type on any measure (see Table II). This suggests that Achievers did not rate their attitude, intention, or self-efficacy differently overall than Conquerors, establishing that there were no group-level differences in the ratings.

Intervention Type. The results also show no main effect of Intervention Type on any measure – attitude, intention, and self-efficacy, suggesting that random assignment of participants to the two intervention types did not yield groups who rated their attitude, intention, or self-efficacy differently overall, (see Table II). This result establishes that the random assignment to the experimental conditions was effective and did not produce bias.

Time by Intervention. In terms of the efficacy of the interventions over time, we also saw no significant interaction between time (pre, post) and intervention type, suggesting that when we do not consider gamer type, there is no significant difference between how a Reward-based or Competition-based intervention affects attitude, intention or efficacy, (see Table II). Without considering gamer type, these results would suggest that the Reward and Competition strategies are not different in their effectiveness; however, considering the 3-way interaction with gamer type shows otherwise.

3-way Interaction between Gamer Type, Intervention Type, and Time. Thus far, we have seen results suggesting that there is no difference in the efficacy of employing a Reward strategy or a Competition strategy in the design of a game for change; however, the significant 3-way interaction shows the beneficial effects of tailoring persuasive games.

Our model predicted that Achievers would respond only to Reward and Conquerors would respond only to Competition (see Table I). The results show that there are significant interactions between Gamer type, Intervention type, and Time for all the three measures – attitude, self-efficacy, and intention (see Table II). The significant three-way interaction on all three measures confirms that gamer type must be considered when evaluating the persuasiveness of a game for change. Pairwise comparison shows that for:

Achievers. Achievers were influenced by the Reward strategy but not the Competition&Comparison strategy for all measures. Specifically, playing JunkFood ALIEN-R (Rewards) motivated an increase in all measures (Attitude: p<.001; Intention: p<.001; Efficacy: p<.001), whereas playing JunkFood ALIEN-C (Competition&Comparison) led to no significant change in all measures (Attitude: p=.691; Intention: p=.094; Efficacy: p=.573), see Figure 4.

Conquerors. Conquerors were influenced by the Competition strategy but not the Reward strategy. Specifically, playing JunkFood ALIEN-C (Competition&Comparison) motivated an increase in all measures (Attitude: p<.001; Intention: p<.001; Efficacy: p<.001), whereas playing JunkFood ALIEN-R (Rewards) led to no significant change in all measures (Attitude: p=.204; Intention: p=.099; Efficacy: p=.672), see Figure 4.

Table II. Results from Repeated-measures MANOVA

	Gamer type	Intervention Type	Time by Intervention	Time by Intervention by Gamer type
Attitude	$F_{1,268}$=1.08, p=.300	$F_{1,268}$=0.44, p=.835	$F_{1,268}$=1.52, p=.219	$F_{1,268}$=41.39, p<.0001, η^2=.13
Intention	$F_{1,268}$=0.17, p=.683	$F_{1,268}$=3.010, p=.084	$F_{1,268}$=0.74, p=.389	$F_{1,268}$=71.81, p<.0001, η^2=.21
Self-Efficacy	$F_{1,268}$=1.27, p=.260	$F_{1,268}$=0.10, p=.747	$F_{1,268}$=0.15, p=.698	$F_{1,268}$=36.11, p<.0001, η^2=.12

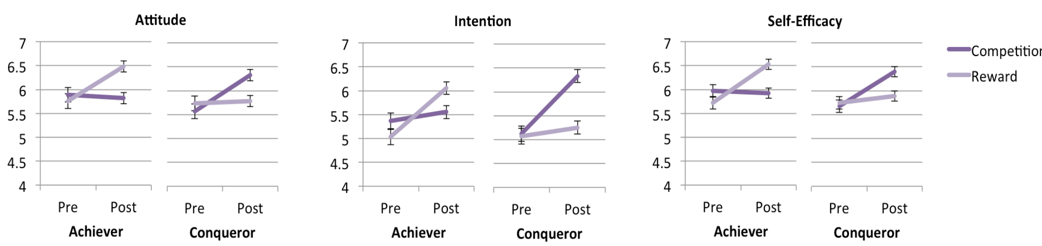


Fig. 4. Means ± SE for Attitude, Intention, and Self-Efficacy by Gamer type and Intervention Type

In summary, our results showed that tailoring the persuasive strategy employed in a game for change to gamer type according to our predictive models produced an intervention that yielded improved attitude, intention and self-efficacy toward healthy eating, thereby answering our first research question of *does tailoring games for change to player type increase their persuasiveness?* Tailoring games for change increases their persuasiveness.

However, it was still unclear whether the tailored games for change were more effective because the persuasive strategies employed were more effective or whether participants were more motivated because they had a better play experience when playing the tailored version. The tailored games were also likely more appealing to players, which could explain the effects on attitude, intention, and self-efficacy. This led us to investigating the second research question:

Does Play Experience Mediate the Effect of Tailoring? To determine whether the benefits of tailoring an intervention are mediated by improved player experience, we conducted parallel mediation regression models [Hayes 2013] of tailoring (tailored, contra-tailored) on attitude change, intention change, and self-efficacy change, with experienced enjoyment, invested effort, perceived competence, and tension as mediators and while controlling for gender. As shown in Figures 5, 6, and 7, there was a total effect of tailoring on attitude change, intention change, and self-efficacy change. The total effect remained a significant direct effect even after play experience measures (enjoyment, competence, effort, and tension) were included as mediators in the model. In addition, although tailoring an intervention increased experienced enjoyment and perceived competence, the bootstrapped confidence intervals for all mediators in all models include zero [Hayes 2013], suggesting no mediation of enjoyment, competence, effort, or tension on how tailoring an intervention improves attitude, intention and self-efficacy; furthermore, the p-value for all normal theory tests were non-significant (all p>0.2). This answers our second research question of *whether the effect of tailoring is mediated by play experience.* Play experience does not mediate how tailoring improves the persuasiveness of a game for change, and is not the casual path of increased efficacy of tailored games for change.

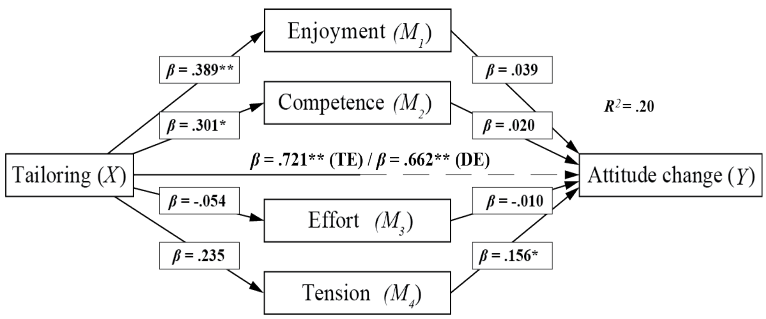


Fig. 5. Parallel mediation model of tailoring on attitude change with play experience as mediator. *p<.05, **p<.01.

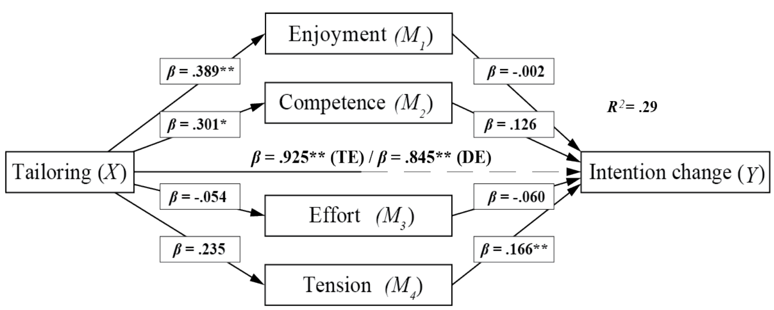


Fig. 6. Parallel mediation model of tailoring on intention change with play experience as mediator. *p<.05, **p<.01.

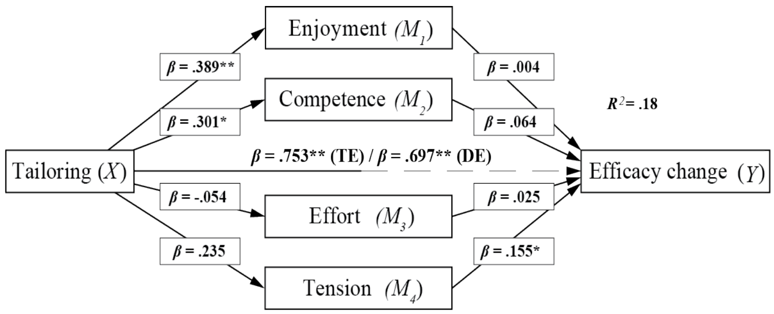


Fig. 7. Parallel mediation model of tailoring on self-efficacy change with play experience as mediator. *p<.05, **p<.01.

8. DISCUSSION AND SUMMARY

It is very tempting in the absence of knowledge, to assume that persuasive strategies when employed in the design of games for change would produce the expected outcome of motivating desirable behavior change irrespective of the target audience or user type. Our experiment tested this assumption by investigating the hypothesis *that tailoring persuasive strategies employed in games for change to gamer type increases their effectiveness at motivating desired behaviour change*. In the first part of our work, we demonstrated that different gamer types are clearly motivated by different strategies and developed models for tailoring persuasive strategies in the design of games for change to gamer types. More specifically, our models show that Achievers are motivated by Reward but not Competition, whereas Conquerors are motivated by Competition but not Reward.

To validate the results of our model in an experiment, and to determine whether or not we could use the results in a prescriptive manner to inform the design of games for change, we designed and implemented two versions of a model-driven game for change promoting healthy eating using Reward and Competition/Comparison strategies and tailored respectively to Achievers and Conquerors. Our results show that for Achievers, the Reward version of our game was more effective than the Competition/Comparison version, while for Conquerors, the Competition/Comparison version was more effective than the Reward version. In summary, our results suggest that for games for change to achieve their intended objective of promoting desirable behaviour change, it is necessary to tailor the games using personalization models of how different gamer types respond to different persuasive strategies.

8.1 Relative and Comparative Efficacy of Persuasive Strategies

Without considering gamer type, our results show that the Reward and Competition strategies are not different in their efficacy overall; however, considering the gamer types shows that the strategies vary in their efficacy depending on the gamer type under consideration. This may explain why many interventions employing the one-size-fits-all approach record varying degrees of success, mixed findings, and even failures [Kaptein et al. 2012]. Given that there are individual or gamer type differences in a sample of people exposed to an intervention, the effect of various strategies adopted in the intervention design may seem equivocal. For example, a competitive game targeting an audience consisting mainly of Conquerors and Achievers or Conquerors and Daredevils would probably result in mixed findings because Conquerors would respond positively to the Competition strategy, but not Achievers or Daredevils – as shown in Table I. Similarly, a Reward-based game targeted at an audience consisting mainly of Achievers and Survivors or Conquerors would probably result in mixed findings, because Achievers would respond positively to Reward, whereas the Survivors or Conquerors would not.

Much discussion has occurred in the games for change community on the value of using Reward schedules (operant conditioning [Reynolds 1975]) to motivate players, because of its focus on extrinsic motivation. It has been argued that using Reward as an incentive to change behavior has the potential of redirecting the intention of a particular activity [Colineau and Paris 2011]. Similarly, [Gneezy and Rustichini 2000] in their study of the effect of small and large Rewards on people's motivation, showed that the introduction of some tangible compensation did undermine performance, especially if the Reward is considered small. This type of research has suggested that rewarding players can demotivate behavior change. Birk et al. [Birk, Mandryk, et al. 2016] support these findings in showing that when intrinsically motivated players of a game for change were compensated with money over the medium term, their intrinsic motivation waned. Our work shows however, that Rewards can be an effective mechanic if well matched to the profile of the player in games. Rewards worked for Achievers, but not for Conquerors; whereas Social Comparison and Competition [Festinger 1954] worked for Conquerors, but not Achievers.

8.2 Using Pop-ups to Capture Attention

Game for change designers often battle with how to design games to manage players' attention and direct them to certain game features that contain important persuasive information. Our work demonstrates one possible way that this can be achieved. As described above, JunkFood Aliens repeatedly interrupted gameplay and displayed the intervention page (which appeared like a pop-up) after every interval. This is contrary to common game design practices; however, it ensures that players pay attention to the persuasive information contained in the intervention page. The results of our study show that this approach was successful at capturing and focusing players' attention to the persuasive message and made players reflect more on the message in general. However, our participants showed some mixed reactions to the interruptions. Some participants liked the fact that the interruptions caused by the pop-up gave them an opportunity to review their performance and re-strategize their gameplay. This is supported by comments such as *"I really like that the game pauses and display my earned badges after every interval. It gives me time to rest and refresh after facing the unending firing and killing by the brutal unhealthy foods*." On the other hand, interrupting the gameplay with the intervention page annoyed some players as shown by comments such as: "*Was kind of annoying, actively playing and enjoying the game, only to have the scoreboard suddenly pop up*." One way of balancing the tension between focusing players' attention on certain features and overwhelming them with frequent pop-ups is to display the pop-ups less frequently or to display at a time that it will cause less interruption in the gameplay, such as at the end of every level and before beginning a new level.

8.3 Design Implications for Games for Change

The findings presented above raise some issues, which have some design implications for games for change and we discuss them below.

8.3.1 Games for Change Designers Do Not Have to Employ Multiple Strategies to Make Their Games Effective.

It is a common practice for designers of games for change to incorporate multiple strategies in a single persuasive game. This is done with the hope that at least one of the strategies will be suitable for motivating behaviour change in the target audience or will appeal to different types of people that may be present in a one-size-fits-all approach, as decisions on which strategies to employ are often based on intuition. The direct result is an overly complex game that may overwhelm the users and lead to cognitive overload [Khaled 2008]. Another problem with using multiple strategies in a single game for change design is that it makes it difficult to evaluate which strategy worked (for which audience) and why they work, thereby making it difficult to adapt the findings from successful games for change in other games for change.

The results from the evaluation of the two versions of JunkFood Aliens, which were designed using single strategies (Reward or Competition and Comparison), show that using a single appropriate strategy in game for change design led to an effective game for change. However, whether or not using multiple strategies will increase the effectiveness of games for change is still unclear. Although, according to [Kaptein 2012], combining multiple strategies in a single persuasive design can lead to an overall reduced persuasive effect, especially when one of the strategies is less effective than the other – "*in some situations using multiple strategies can be detrimental as compared to the presentation of a single, correct, strategy*". In the absence of personalization models (such as the one presented in this paper) for selecting appropriate strategies for tailoring games for change, there is a greater probability of using a combination of appropriate and inappropriate strategies or a combination of inappropriate strategies in a game for change design and that would be ineffective. However, this does not mean that using a combination of appropriate strategies in the design of games for change will result in games that are significantly more effective than those designed using a single appropriate strategy. Research has found that even in situations where two or more strategies are equally effective, "*the persuasion does not always add up*" [Kaptein 2012]. This suggests that combining multiple preferred strategies in game for change design may not produce an additive effect with respect to promoting desired behaviour change. As a result, designers should be cautious when using multiple strategies in a game to promote change of a single action [Kaptein 2012]. Tailoring games for change using a single appropriate strategy as identified in the personalization model should lead to a simple and effective game for change.

We chose a simple game design with the intention that by reducing the persuasive rhetoric of the game to a simple "veggies and fruits are good, whereas junk food is bad" narrative, we reduced potential interactions between the persuasive rhetoric and narrative of the game and persuasion of the strategies employed. This approach reduced potential interactions between the game and the strategy in our study; however, future work should investigate the interaction between the persuasive rhetoric of the game and the persuasive strategy employed. It is possible that different types of games for change would yield different advantages of tailoring.

8.3.2 Games for Change Can Be Tailored by Adapting Only the Strategies Employed

One of the drawbacks to tailoring game-based interventions is the cost – the level of work involved in designing/adapting games for change for each user type. The success of the two versions of JunkFood Aliens shows that game designers do not have to design each game version from scratch to adapt to the target audience. Tailoring can easily be achieved by incorporating appropriate strategies into existing games for change. Designers can easily adapt the strategies without making significant changes to the games, as exemplified in the design of the two versions of JunkFood Aliens. The success of tailored JunkFood Aliens implies that existing games for change can be adapted to suit the target audience by incorporating appropriate persuasive strategies following the personalization models presented in this paper. Our personalized models provide an effective guideline for tailoring games for change to the gamer type to increase the efficacy of the game achieving the intended objectives. Designers of games for change can easily select the appropriate strategy to tailor their games to the target audience depending on their gamer type. The model could guide designers in deciding on not only the strategies to employ when designing games targeting various gamer types, but more importantly the strategies to avoid.

9. LIMITATIONS AND FUTURE WORK

There are three main limitations to this work. First, it must be noted that our research is limited to the context of a game designed to promote attitude, intention, and self-efficacy change toward healthy eating and should be extended to other domains. Furthermore, we measure attitude change, intention to change, and self-efficacy to change. These factors are all precursors to actual behaviour change; however, future work should investigate whether the increased efficacy of tailored games for change translates into differences in behaviour.

Second, the study participants were recruited from Amazon Mechanical Turk (AMT). Although, AMT has become an accepted method for gathering users' responses and it ensures efficient survey distribution and high quality data, it is likely that not all AMT participants are psychologically engaged and are motivated by the compensation they receive. Therefore, the results of this study may not necessarily generalize; hence future research should compare the results with participants recruited from other domains, especially people who are intrinsically motivated to change their behaviour.

Finally, we investigated the effectiveness of tailoring and the validity of our personalization model using only two gamer types (Achievers and Conquerors) out of the seven BrainHex types and two persuasive strategies (Competition and Reward). The results for other gamer types may vary. However, the paper sets out a clear research agenda showing how the rest of the model can be tested.

Future research would focus on conducting a longitudinal randomized control trial of the two versions of JunkFood Aliens to establish their efficacy with respect to motivating actual behavior change. It would be also interesting to investigate for possible domain dependency of our personalization models by applying them in designing games for change targeting other domains. Investigating and comparing the efficacy of a game designed using a single appropriate strategy versus multiple strategies would extend existing knowledge in this research area. We hope to examine if actual game performance mediates the effect of tailoring on the effectiveness of games for change. Finally, future research should investigate how to automatically determine player personality type during the game.

10. CONCLUSIONS

Games for change are increasing in prevalence and help people improve their lives and well-being in contexts as diverse as sustainability, health, and education. Providing designers of games for change with the tools to personalize their games – such as unobtrusive modeling of relevant user features and predictive models, allowing for the dynamic selection of appropriate persuasive strategies – will increase the efficacy of the games, benefiting the increasing population who rely on them for self-improvement. This paper contributes in advancing the field of HCI and games for change design specifically by effectively answering two important research questions of (1) *does tailoring games for change to player type increase their persuasiveness, and* (2) *are the beneficial effects of tailoring mediated by improved play experience.* The paper showed that *one size does not fit all* – it effectively demonstrated that tailoring games for change will increase their effectiveness at motivating behaviour change through design, implementation, and large-scale study of the persuasiveness of a tailored and contra-tailored version of a game for change called JunkFood Aliens. Furthermore, we showed that although tailoring an intervention improved play experience, play experience (enjoyment, competence, effort, or tension) does not mediate how tailoring an intervention improved the persuasiveness of a game for change, with respect to attitude, intention and self-efficacy change. This answers the second research question and shows that *the increased efficacy of tailoring cannot be attributed to the improved play experience.*

One of the drawbacks of tailoring game-based interventions is the cost; tailoring has always been thought of as very tedious task. We showed that tailoring games for change can be achieved by adapting only the strategies employed to be appropriate for the gamer type under consideration. Finally, we also showed that persuasive strategies vary in their comparative efficacy depending on the gamer type under consideration. Our personalization models can guide game designers in deciding on the strategies to employ to tailor their games for change.

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