Tailoring Persuasive Health Games to Gamer Type

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ABSTRACT
Persuasive games are an effective approach for motivating health behavior, and recent years have seen an increase in games designed for changing human behaviors or attitudes. However, these games are limited in two major ways: first, they are not based on theories of what motivates healthy behavior change. This makes it difficult to evaluate why a persuasive approach works. Second, most persuasive games treat players as a monolithic group. As an attempt to resolve these weaknesses, we conducted a large-scale survey of 642 gamers' eating habits and their associated determinants of healthy behavior to understand how health behavior relates to gamer type. We developed seven different models of healthy eating behavior for the gamer types identified by BrainHex. We then explored the differences between the models and created two approaches for effective persuasive game design based on our results. The first is a one-size-fits-all approach that will motivate the majority of the population, while not demotivating any players. The second is a personalized approach that will best motivate a particular type of gamer. Finally, to make our approaches actionable in persuasive game design, we map common game mechanics to the determinants of healthy behavior.

Author Keywords
Games design; persuasive game; gamer types; serious games; health; behavior theory, HBM, player typology

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Recent years have witnessed an increase in lifestyle-related health problems (e.g., obesity, sedentariness). As a result, research efforts have focused on ways of encouraging healthy behavior change. In one approach, researchers have investigated what motivates people to change their behavior. In another approach, persuasive games for health – which are designed as interventions with the primary purpose of changing a user's behavior or attitude in an intended way [7] – have been used to promote health behavior change. The former line of research has resulted in several theories of human behavior (e.g. [1,31,33]), whereas the latter has resulted in several persuasive games that have shown to be effective tools for promoting health and well-being by effecting behavior change in a desired manner [17,24,25,29].

Despite this growing interest in game-based interventions for behavior change, current persuasive games suffer two major limitations: first, although research has shown that interventions that are informed by theories and models tend to be more successful than those based on intuition [16], most persuasive games to date are not based on the theories of what motivates behavior change (e.g., [24,25]). This makes it difficult to evaluate what persuasive approaches worked and why they worked. Even when the theories are mentioned, it is usually unclear how the theoretical determinants (variables) were translated into game mechanics (for example see, [14,22]). This makes it difficult for designers of persuasive games to apply research findings from successful persuasive game interventions in their own game designs that may target a different behavior. The second limitation is that most persuasive games adopt a one-size-fits-all approach to their intervention. Various research on gameplay motivation has shown that treating gamers as a monolithic group is a bad design approach [5,6,41] – only considering what works for one individual may actually demotivate behavior change in others.

In this paper, we resolve these two weaknesses by proposing two theory and data-driven approaches for developing persuasive games to motivate health behavior change – one that is an all-purpose solution, and one that is personalized for the game play style of the target users. Our design guidelines are based on a quantitative study of 642 gamers, where we surveyed their eating behavior and the associated determinants of healthy eating. We employed Confirmatory Factor Analysis (CFA) and used Partial Least Square (PLS) Structural Equation Modeling (SEM) to develop a model of healthy eating determinants for various gamer types. Our study is based on the seven gamer types (*achiever, conqueror, daredevil, mastermind, seeker, socializer,* and *survivor*) identified by the BrainHex model [6], and the health determinants (*perceived susceptibility, perceived severity, perceived benefit, perceived barrier, cue to action,* and *self-efficacy*) identified by the Health Belief Model (HBM) [33], one of the oldest and the most widely employed models of health behavior promotion.

Our models reveal several differences in the impact of various determinants on the seven gamer types' likelihood of healthy behavior. For example achievers are mostly influenced by *perceived susceptibility* (what they stand to lose), while conquerors care more about what they stand to gain (*perceived benefit*) in relation to health behavior. Based on the results of our models, we propose two approaches for designing persuasive games: a 'one-size-fits-all' approach that will appeal to the majority of gamer types, while not disadvantaging any, and a personalized approach that tailors persuasive games for healthy behavior change to gamer type. To make our findings actionable for designers of persuasive games, we suggest mappings of the determinants of health behavior to common game mechanics that can be employed in persuasive game design.

To the best of our knowledge, this study is the first to link research on the psychology of player typologies (as identified by BrainHex) with the psychology of health behavior change (as identified by HBM) to find patterns in gamers' motivation that can inform the choice of game mechanics for designing games that will motivate behavior change. It is also the first to suggest data-driven and gamer type-relevant game design approaches that are actionable for designers and developers of persuasive games for motivating health behavior. Our paper shows that having a personalized persuasive profile of what motivates different gamer types, and mapping these theoretical motivators to game mechanics, provides a crucial theoretical and methodological bridge between research on what motivates health behavior change (i.e., theories) and research on designing games for health (i.e., persuasive games).

RELATED WORK

In this section we present an overview of behavior change theories, with a focus on the HBM. This is followed by a review of persuasive games for health behavior change and the underlying theoretical determinants. We conclude by presenting a brief overview of gamer types with an emphasis on the BrainHex model.

Behavior Change Theories

Health behavior theories assist in understanding health behavior problems, developing interventions based on salient determinants that affect behaviors, and evaluating the effectiveness of the health interventions. The most effective persuasive interventions for behavior change usually occur when the intervention is behaviorally focused and theory driven [13]. It follows to say that persuasive games can be made optimally effective if they are also informed by these theories [28,36]. According to Kharazzi et al. [26], using behavioral models to inform game-based interventions for health can increase the usability and the effectiveness of the games at achieving the desired outcomes. Several health behavior theories have been used to inform persuasive intervention designs, such as the Theory of Planned Behavior [1], the Transtheoretical Model [31], and the Health Belief Model [33]. However, the Health Belief Model (HBM), developed in the 1950s to investigate why people fail to undertake preventive health measures, remains one of the most widely employed theories of health behavior [33]. The HBM was developed to address problem behaviors that evoke health concerns. It postulates that an individual's likelihood of engaging in a health-related behavior is determined by his/her perception of the following six variables:

Perceived susceptibility – perceived risk for contracting the health condition of concern;
Perceived severity – perception of the consequence of contracting the health condition of concern;
Perceived benefit – perception of the good things that could happen from undertaking specific behaviors;
Perceived barrier – perception of the difficulties and cost of performing behaviors;
Cue to action – exposure to factors that prompt action; and
Self-efficacy – confidence in one's ability to perform the new health behavior).

These six health determinants identified by HBM together provide a useful framework for designing both long and short-term behavior change interventions [16]. HBM focuses mainly on health motivators; therefore, it is most suitable for addressing problem behaviors that have health consequences (e.g., unhealthy eating and physical inactivity). HBM has been adapted and successfully applied in the design of many persuasive games for health [26,30].

Game-Based Interventions

Persuasive technology aims to bring about desirable change in attitude and/or behavior without using coercion or deception [7]; persuasive games are persuasive technologies that use game-based approaches in their intervention design. Studies have shown that games can be an effective approach for effecting behavior change in an intended manner [24,29]. 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 [38]. Bogost used the term *persuasive game* to describe video games that mount procedural rhetoric effectively [8]. However, for the purpose of this paper, we define persuasive games as games that are designed with the primary purpose of changing a user's behavior or attitude using various behavior change theories and strategies [7].

Persuasive games have been applied in many domains including education, sustainability, and health. In the health domain, persuasive games can broadly be categorized into two main areas: *persuasive games for health promotion and prevention* and *persuasive games for disease management*.

Persuasive Games for Health Promotion and Prevention

Preventative health behaviors include behaviors that are undertaken by individuals for the purpose of preventing illness, detecting early illness symptoms, and maintaining general wellbeing [36]. Examples include healthy eating, being physically active, and performing breast self-exams. Several persuasive games have been developed for health promotion and prevention. *LunchTime* is a slow-casual game for motivating healthy eating [29]. Players play the role of a restaurant visitor, and the goal is to choose the healthiest option from a list of food choices; points are awarded based on the relative healthiness of the choice. The point reward can be likened to a *perceived benefit* associated with the healthy choice (choosing a healthy food option). Similarly *OrderUP!* aims to help players learn strategies for healthy eating choices by having them play the role of a server in a neighborhood restaurant [17]. In contrast to *LunchTime, OrderUP!* portrays the perceived threat (*susceptibility* and *severity*) associated with making unhealthy meal choices by making players lose points for unhealthy choices. The decrease in cumulative points (representing a reduction in health value) portrays how eating unhealthy meals decreases one's general wellbeing and makes one *susceptible* to various health problems. Studies showed that playing the LunchTime and OrderUP! games increased the players' nutrition knowledge and their general feeling of *self-efficacy*.

Escape from Diab is an adventure game on healthy eating and exercise, with the main goal of preventing kids from becoming obese and developing diabetes and other related illnesses [39]. *Escape from Diab* employed several strategies to impact players' health belief and motivate behavior change. These included modeling, goal review, and feedback – increasing *self-efficacy*, problem solving – impacting skills to overcome *perceived barrier,* and self-monitoring – impacting *perceived susceptibility, severity,* and *cue to action*. Finally, another successful application of *perceived barrier, benefit, susceptibility severity, and self-efficacy* can be seen in the strategies implemented in a smoking cessation application called *Smoke?* [24]. *Smoke?* is a narrative simulation game that presents six weeks of the life of a virtual character called MC. The player controls MC 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. At the end of the game, players observe the *benefits* associated with their decisions and how their decisions have affected MC's life negatively – *susceptibility* and *severity*. Players also learn and increase their *self-efficacy*. The results from the evaluation of the game-based interventions show a varying degree of success at achieving various health objectives. However, it is not always obvious which of the persuasive approaches employed made the games successful.

Persuasive Games for Disease Management

Persuasive games have also been used to help patients improve health-related self-management skills. These include teaching them how to manage certain illnesses, helping them comply with treatment directives by delivering health-related information, modeling and simulating health behavior, and providing opportunities for players to rehearse health behaviors in relation to a specific health condition/illness [23]. Games in this category are targeted at those who consider themselves ill with the intention of helping them manage their illness or get well. For example, a game called *Re-Mission* was designed to improve cancer treatment for young adults and adolescents [22]. The task of the players of *Re-Mission* is to control a nanobot name Roxxi. Roxxi moves through the body of the cancer patients destroying cancer cells and tumors with chemotherapy and radiation – depicting the *perceived benefit* of chemotherapy. The result of the evaluation of Re-Mission revealed that patients who played Re-Mission showed increased knowledge and *self-efficacy* in relation to cancer management than patients in the control group. *SnowWorld* is a virtual reality game developed to provide a means of pain management for burn patients [21]. The game manipulated the *perceived severity* of the pain by immersing players in a virtual world where they fly through an icy landscape of cold rivers and waterfalls with gently falling snow. The evaluation of *SnowWorld* showed that it was effective in reducing pain perception among patients. *Watch, Discover, Think, and Act (WDTA)* was designed to educate children with Asthma on various triggers, signs, and corresponding actions for asthma self-management [36]. It models game challenges after asthma challenges. The game employed *cue to action, perceived susceptibility, perceived severity, barrier* and *self-efficacy.* The game challenges a child to monitor asthma symptoms and environment triggers (*cue to action*)*,* discover if asthma exists and possible causes (*perceived susceptibility*)*,* and then think and take action (*health behavior action*). WDTA also increased the players' feeling of capability (*self-efficacy*) using symbolic modeling and rehearsal. In summary, a typical scenario in disease management games is that players take care of and help a game character control symptoms and manage diseases in various settings. This increases the player's self-management skills, related knowledge, and self-efficacy.

This review of games used for health-related purposes shows that games can be strategically designed to affect important health beliefs among players. However, most of the existing game-based interventions suffer two major limitations: firstly, there is often no predetermined mapping of the behavioral determinants from human behavior theories to game mechanics. The majority of existing persuasive games do not even specify the theories that inform their design – for those that state the theories; it is not clear how the various theoretical determinants are translated into game mechanics. This makes it difficult to evaluate what persuasive approaches worked and why they worked. Secondly, they use a one-size-fit-all approach even though research has shown that players differ in both behavior and motivation [9,41].

Gamer Types

One way that players differ is in their preferred play style. By tailoring games to a player's preferred style, games can be made relevant to the player and interesting to repeat. Research on gameplay and players' motivation has shown that different people play games for myriad reasons, therefore, it is inappropriate to treat gamers as a monolithic group [9,41]. Consequently, attempts have been made to classify gamers into various personality types commonly referred to as gamer types. One popular classification is Bartle's four gamer types (*Achiever, Explorer, Socializer,* and *Killer*) [5]; however, this model was based on intuition. It has not been validated with empirical data, nor has it been shown that the four types are independent. Bartle extended his model to 8 types for play within virtual worlds [4] but this classification has also not been validated with data. Yee [42] performed factor analysis of survey data from 3000 players of massively multiplayer online role playing games (MMORPGs) and revealed that players have three main (and non-independent) motivations: achievement, socialization, and immersion. These motivations are grounded in data, but do not define the primary play style of a gamer, which is how we want to tailor games.

The BrainHex model of seven gamer types [43] is a relatively new model, but is based on neurobiological foundations; in addition, it has been validated with large numbers of participants [27]. The BrainHex model identifies 7 types of players.

Achievers are goal-oriented and motivated by the reward of achieving long-term goals [27]. Therefore, an achiever often gets satisfaction from completing tasks and collecting things (e.g., points).

Conquerors are challenge-oriented. They enjoy struggling against impossibly difficult foes before eventually achieving victory and beating other players [27,43]. They exhibit forceful behaviors, channel their anger to achieve victory and thus experience fiero (an expressions of pride and emotion following victory over difficult challenge).

Daredevils are excited by the thrill of taking risks and enjoy playing on the edge. The enjoyment of game activities such as navigating dizzying platforms, rushing around at high speeds while still in control characterizes the Daredevil.

Masterminds enjoy solving puzzles, devising strategies to overcome puzzles that defy several solutions, and making efficient decisions.

Seekers enjoy exploring things and discovering new situations. They are curious, have sustained interest, and love sense-simulating activities.

Socializers enjoy interacting with others. For instance, they like talking, helping, and hanging around with people they trust. Socializers are trusting and easily angered by people who abuse their trust.

Survivors love the experience associated with terrifying scenes and the thrill of escaping from scary situations.

BrainHex is of interest because of the theory on which it is based. It describes each gamer's play style and clearly connects this to the types of preferred gameplay elements. Moreover, participants do not choose their gamer type through introspective choosing of a category – BrainHex includes 28 questions to classify participants into various gamer types. This allows for more accurate classification, as participants might not be good at classifying themselves.

STUDY DESIGN AND METHODS

Our study was designed to elicit participants' responses to surveys that would assign a gamer type and weightings to the six determinants of healthy behavior identified by the HBM. We were specifically interested in the relationship between the six health determinants (*perceived benefit, perceived barrier, perceived susceptibility, perceived severity, cue to action, self-efficacy*) and *health behavior* as they apply to decisions around healthy eating behavior. Research has shown that good eating behavior can prevent – or at least reduce the risk of – many diseases including obesity, heart disease, and diabetes [40]. Therefore, eating behavior is a focus of many persuasive games [17,29]. In this section, we first describe how we developed the research instrument; this is followed by data collection methods and validation of our analyses.

Measurement Instrument

The online survey consisted of questions on participants' demography, questions of the HBM determinants, and questions for classifying gamer type. The questions used in measuring the six HBM determinants were constructed based on guidelines developed by Abraham and Sheeran [12], and have been validated on healthy eating by Sapp and Jensen [34] and Deshpande [15]. All of the HBM variables were measured using participant agreement with a 7-point Likert scale ranging from "1 = Strongly disagree" to "7 = Strongly agree". These HBM determinant questions included: (1) seven questions measuring perceived benefit (BEN) – e.g., eating healthy diets most of the time would be beneficial to me; (2) seven questions measuring perceived barrier (BAR) – e.g., eating a healthy diet is costly/hard; (3) two questions measuring perceived susceptibility (SUS) – e.g., If I don't eat healthily, I will be at high risk of some dietary-related diseases; (4) two questions measuring perceived severity (SEV) – e.g., the thought of ending up in the hospital due to dietary-related diseases scares me; (5) four questions measuring cue to action (CUA) – e.g., I would pay more attention to my meal choices if friends and family members suggest it; (6) three items measuring self-efficacy (EFF) – e.g., I am confident that I could eat healthily within the next two weeks if I want; and (7) five items measuring likelihood of behavior – e.g., I intend to make healthy meal choices most of the time in the next two weeks. We also included the 28 BrainHex questions [43] to classify the participants into various gamer types. We recruited participants through posted announcements in high traffic websites and forums.

Participants

Data for this study were collected over a period of one year (from August 2011 to August 2012). A total of 710 responses were received, of which 642 were usable responses – i.e., from those who were at least 18 years old at the time of data collection, and were game players. This is in compliance with the study ethics approval and to ensure that the participants were of legal age to make decisions independently (including decisions on what to eat). Participants were all computer or video game players to ensure accurate classification and mapping to the gamer types. The gamer types were well distributed across our population: *achiever* (110, 17%), *conqueror* (88, 14%), *daredevil* (67, 10%), *mastermind* (138, 22%), *seeker* (91, 14%), *socializer* (81, 13%), and *survivor* (67, 10%). This is similar to BrainHex [43] where *masterminds*, *seekers*, *conquerors*, and *achievers* are the dominant gamer types. The ages of participants were also well distributed: 18-25 (307, 48%), 26-35 (186, 29%), 36-45 (76, 12%), and over 45 (73, 11%). This distribution is similar to [2], which shows that the average age of digital game players is 30 and 63% of players are younger than 36 years. 48% (306) of our participants were male and 52% (336) were female.

Measurement Validation

To determine the validity of our survey instrument we performed Principal Component Analysis (PCA) using SPSS 19. Before conducting PCA, the Kaiser-Meyer-Olkin (KMO) sampling adequacies were all > .70 and the Bartlett Test of Sphericity was significant at p<. 001. Thus, the data was suitable to conduct factor analysis [20]. Each question loaded onto their corresponding factors and the corresponding factor scores (weights) were all >.70.

Confirmatory Factor Analysis

HBM is comprised of six determinants of healthy behavior – SUS, SEV, BEN, BAR, CUA, and EFF. To verify that our data replicate the six factors in healthy eating behavior, we conducted Confirmatory Factor Analysis (CFA – a statistical procedure that compares the fit of the data with the factor being modeled) using Partial Least Square (PLS) Structural Equation Modeling (SEM). PLS is especially recommended for theory formation and verification [19]. Moreover, PLS-Structural Equation Modeling has less stringent requirements concerning data distribution assumptions [19] and can accommodate small sample sizes as opposed to covariant-based SEM. In the CFA, the six factors were included as latent (independent) variables, and each was hypothesized to have a direct effect on health behavior – the dependent variable.

Multi-Group Comparison

Prior to comparing our models, we tested for measurement invariance across the seven gamer types. This is important because the psychometric properties from the samples must be demonstrated to have the same structure to establish that the groups had similar interpretations of our instrument's items. Failure to establish measurement invariance would suggest that we measured different phenomena across the groups, therefore making comparison between groups meaningless [35]. To assess measurement invariance, we used the component-based CFA in SmartPLS 2 [32] to conduct factor analysis for each group of data and retained items that had factor loadings of at least .5 [18] in all the groups (and dropped for all groups items with loadings less than .5), thereby establishing configural invariance. After configural invariance was established, we also assessed and established metric (equivalent factor loadings) and scalar invariance (equivalent intercepts) by first running bootstrap analyses using a resample size of 1000, and generating the standard error (SE) for each item weight in each group. Next, we ran PLS algorithm for each group and recorded the actual weight. We calculated t-statistics and corresponding p-values to see if there were significant differences across the groups (at $p < .05$) using the weight, SE, and sample size in each group. Items that were significantly different were dropped for all groups. We repeated this analysis until the results were stable and we repeated the same process for indicator loadings. We also examined latent score differences across groups. This process established measurement invariance and ensured that our data were suitable for multi-group comparison.

We report here the common set of indices recommended for model validity and reliability in PLS. We used SmartPLS 2 [32] to analyze the model. Indicator reliability can be assumed because Cronbach's α and the composite reliability that analyze the strength of each indicator's correlation with their variables are all higher than their threshold value of 0.7 [10]. Convergent and discriminate validity can be assumed as all constructs have an Average Variance Extracted (AVE) (which represents the variance extracted by the variables from its indicator items) above the recommended threshold of 0.5 and greater than the variance shared with other variables [10]. The measurement models yielded an acceptable value of all indices for PLS model validity or reliability.

Moderating Effect

A proper comparison of the models cannot be achieved without establishing that the models' estimates are significantly different. To access for significant structural differences between the gamer types, we used the pairwise comparison approach recommended by Chin [11]. Specifically, we used PLS algorithm in SmartPLS 2 to separately estimate path coefficients (β) for each group. Then, we used bootstrap resampling technique to calculate standard error (SE) for each path. With the β, SE, and the sample size, we calculated t-statistics and the corresponding p-value to test for significant differences between path estimates of different gamer types. We controlled for familywise type I error (due to multiple comparisons) using Bonferroni adjustment. Our result shows that only 39 of the 126 pairwise comparisons were not significantly different. This high percentage of significant differences shows the moderating effect of gamer type.

RESULTS

To examine the differences in the interactions between the six determinants and the outcome of health behavior, we developed seven models (one for each gamer type).

The Structural Model

The structural models determine the relationship between the determinants and health behavior. An important criterion to measure the strength of the relationship between variables in structural models is to calculate the level of the path coefficient (β) and the significance of the path coefficient (p) [18]. Path coefficients measure the influence of a variable on another. The individual path coefficients and their corresponding level of significance obtained from the seven models are summarized in Table 1.

Comparison of Health Behavior Determinants for the Seven Gamer Types

The results from the models show that the seven gamer types (*achiever, conqueror, daredevil, seeker, socializer,* and *survivor*) differ with regards to the influence of the determinants (SUS, SEV, BEN, BAR, CUA, and EFF) on their likelihood of adopting healthy behavior (see Table 1). We discuss and compare the influence of the determinants on the gamer type in the following sections.

Factors	SUS	SEV	BEN	BAR	CUA	EFF
Achiever	**.44**	-.24	-.30	**-.39**	**.31**	.26
Conqueror	-	-	**.48**	**-.38**	**.58**	-
Daredevil	.20	-.36	**.35**	-	**-.46**	-
Mastermind	-	**.35**	-	**-.29**	**.35**	.37
Seeker	-.17	-	.25	-	.37	.24
Socializer	.15	-	.17	-.31	.25	.22
Survivor	-.15	-	**.35**	**-.36**	-	-
SUS = perceived susceptibility, SEV = perceived severity, BEN = perceived benefit, BAR = perceived barrier, CUA = cue to action, EFF = self-efficacy						

Table 1. Standardized path coefficients and significance of the models. Bolded coefficients are p<.001, non-bolded are p<.05 and '-' represents non-significant coefficients.

Perceived Susceptibility

HBM proposed that increasing an individual's perceived risk (susceptibility) associated with a particular health behavior could be an effective way of motivating health behavior change. Surprisingly, the results from our model show that risk perception is only an important motivator of behavior change for *achievers, daredevils,* and *socializers*. In fact, designing a persuasive game to increase the perceived risk associated with a health behavior has no effect on the likelihood of behavior for *conquerors* and *masterminds* and can actually deter *seekers,* and *survivors* from performing the healthy behavior. The potential risks associated with unhealthy behaviors is illness and in the extreme case, death. *Susceptibility* can be seen as a potential loss of a healthy and disease-free life. This is often modeled as loss of object or material possession of value (disincentive) in games [17] with the hope that players will be motivated to perform healthy behaviors to reduce or avoid the associated risk. The use of this loss-framed mechanic has been questioned, and research has therefore examined the effects of potential loss or gain framing on an individual's motivation, finding that some people are more motivated by loss-framed information while others are motivated by gain-framed information [37]. Our results agree, and define these differences further by suggesting that *achievers, daredevils,* and *socializers* care about what they stand to lose (loss avoidance) while *conquerors, seekers,* and *survivors* care more about what they stand to gain in relation to health behavior (as can been seen from their interaction with *perceived benefit* in Table 1).

Perceived Severity

HBM theorized that the perceived seriousness (*severity*) of the consequences of developing a health condition could positively influence an individual's behavior. From the results of our model, *severity* is in fact a significant positive motivator of health behavior for *masterminds* only. This is in line with their gaming style of making sound decisions. However, increasing the perceived consequences of unhealthy behaviors can demotivate *achievers* and *daredevils* from changing the unhealthy behavior and adopting the healthy alternative. This result is in line with previous research that found *severity* as a weak predictor that might even lead to behavior avoidance [3]. This is probably because increasing the magnitude of the perceived consequences associated with unhealthy behavior might make it appear unreal and uncontrollable to *achiever* and *daredevil.* They seem to care more about the perceived risk and not the magnitude of that risk (perhaps the *achiever* sees the outcome as out of reach, whereas the *daredevil* laughs in the face of danger). Similarly, the effect of perceived severity is not significant for *conqueror, seeker, socializer,* and *survivor*. Therefore, portraying the consequences of unhealthy behavior might not necessarily increase the chances that they will change their behavior.

Perceived Benefit

Surprisingly, *perceived benefit* is a differentiator between *achiever* and other gamer types. As proposed by HBM, *benefit* influences the likelihood of health behavior performance positively for *conquerors*, *daredevils*, *seekers*, *socializers*, and *survivors*. However, *benefit* has no significant impact on *masterminds,* whereas it influences *achievers* negatively. The negative association of benefit with achievers contradicts the HBM prediction [33]; however, it supports some other findings that *benefit* does not statistically influence the likelihood of healthy eating [15]. A possible explanation is that adopting a healthy behavior is a lifestyle that spans over a lifetime with no quantifiable benefit. An *achiever* – although goal oriented and motivated by long-term achievement – is more focused on completing tasks and collecting something (e.g., points). Therefore, they are demotivated from performing tasks that have no foreseeable date of completion and collection of accrued benefits. Breaking health behavior into intermediate goals with intermediate and quantifiable benefit might motivate achievers better.

Perceived Barrier

As expected, *barrier* significantly influences all the gamer types negatively with the exception of *daredevils* and *seekers* who do not show significant reaction to perceived barrier but are significantly motivated by benefit. Therefore, creating successful persuasive games targeting *daredevils* and *seekers* will likely require designers to increase the perceived benefit more than lowering the cost (barrier) of adopting the healthy behavior. People usually weigh the benefit and cost to decide on their line of action.

Cue to Action

Cue to action – which can be thought of as any event or stimuli that triggers the performance of a target behavior – is positively associated with health behavior for all gamer types except for *survivors* (not significant) and *daredevils* (negative association). This implies that extensive use of various cues to action (e.g., prompts, reminders, alerts, biofeedback) will be effective at motivating health behavior performance for most gamer types. The negative influence of cue to action on the daredevil's likelihood of health behavior is the major differentiator between daredevils and other gamer types. One possible explanation is that daredevils are thrill seekers and are not interested in reminders to maintain good behavior.

Self-efficacy

As expected, *self-efficacy* is the only determinant that does not influence any gamer type negatively. However, its influence is only significant for *achievers, masterminds, seekers,* and *socializers*. This implies that designing to increase an individual's confidence in his or her ability to perform the health behavior will motivate a positive behavior change for most gamers while not harming others. Persuasive game designers should therefore use various mechanisms (e.g., feedback, graded task, incremental goal setting, rehearsal) to promote self-efficacy.

DISCUSSION

We first present two approaches for applying our model results to persuasive game design. We then describe the limitations of our study and opportunities for future work.

Game Mechanics and HBM

Based on an analysis of related work on game mechanics, we identify a number of ways in which the HBM can be integrated into games by mapping the six determinants (SUS, SEV, BEN, BAR, CUA, and EFF) to common game design mechanics. Because there is no definitive list of mechanics and categories, we executed an affinity mapping exercise on existing lists of game mechanics (e.g., [44,45]), resulting in the 7 categories of mechanics shown in Table 2. We then mapped the mechanics to the determinant(s) that best matched. For example, for the mechanic quest, within the category game elements, we chose *cue to action* and *barrier*. Quests are tasks that players must complete, providing both guidance on what to do next (CUA) and limits to progression in the game (BAR).

"One Size Fits All" Persuasive Game Design

We discuss how our findings can be applied to the design of persuasive health games for the broadest audience, to appeal to the majority of players without demotivating any.

Our results show that *self-efficacy* is perceived as positive by *achievers*, *masterminds*, *seekers* and *socializers* and does not negatively impact other gamer types. Therefore, to appeal to a broad group of players, persuasive game designers should ***include game elements that address self-efficacy***. For example, the player-related mechanics of ownership, loyalty, and pride relate to self-efficacy, while the game elements of repeating simple actions and cascading information will build self-efficacy within the context of playing the game. Urgent optimism should be an effective approach, as long as the game can create in players the belief that they will succeed.

The determinants of *cues to action* and *perceived benefits* only have a negative relationship with one gamer type each. Given the even distribution of gamer types, including these two determinants in persuasive games for broad audiences would only have potential negative effects on a small group of players while being beneficial for the majority of users. Therefore, games designers should ***include mechanics that support cue to action and demonstrate the benefits of behavior change to appeal to a majority of the population***. For example, most reward-based mechanics (e.g., levels, points) can reinforce the benefits of healthy behavior, while behavioral momentum and blissful productivity are in line with the positive message of *perceived benefit*. Mechanics that structure play (e.g., quests, appointments, and cascading information theory) give players an idea of how to change their behavior in stages and with reminders (*cue to action*).

Our results showed that *perceived barriers* have a negative impact on most gamer types, and no effect on *daredevils* or *seekers*; no gamer type was motivated by *perceived barrier*. Therefore, game designers should ***avoid game elements that allude to barriers to the adoption of healthy behavior***. There are several game mechanics from our list that should be avoided or applied very carefully. Disincentives and extinction of rewards are two mechanics that might not be effective with any gamer type. This is in line with recent work showing how negative reinforcements might not be as effective for behavior change as positive reinforcements [14]. In addition, some mechanics have to be carefully applied to avoid reinforcing barriers. For example, quests, which support cue to action (and are thus desirable), must not present so many barriers that the player is demotivated.

Personalized Persuasive Game Design

Although designing for the broadest possible audience is a good practice, there are situations in which personalizing game experience for a particular user might be appropriate.

For example, consider the task of building a voluntarily-played persuasive MMORPG (massively multiplayer online role-playing game). MMORPGs are most enjoyed by the

Category	Mechanic	Explanation
Player	Ownership	Controlling something, "your" property
	Pride	Feeling of joy and ownership after accomplishment
	Envy	Striving for what other players have
	Loyalty	Positive connection with game element leading to ownership
Social	Communal discovery	Community has to work together to overcome obstacle
	Social fabric of games	People grow closer after playing together
	Privacy	Certain information is shared, certain information is kept private
	Viral game mechanics	Game elements which are more enjoyable or only accessible with others
	Companion gaming	Cross-platform gaming
Leaderboards	Achievements	Virtual / physical representation of accomplishment
	Leaderboards	Leaderboards to display highscores
	Status	Rank or level of player
Rewards	Levels	Players receive points for actions, can level up, gain new abilities
	Physical goods	Distribute physical goods to reward players
	Virtual items	Distribute virtual items to reward players
	Reward schedules	Variable and fixed intervals
	Lottery	Give players opportunity of winning stuff
	Free lunch	Give players free gifts
	Points	Measurement of success of in-game actions
	Extinction	Taking reward away
	Disincentives	Punishing player to trigger behavior change
	Loss aversion	Not punishing player as long as desired behavior is shown (but not rewarding either)
	Bonuses	In-game reward for overcoming challenges to reinforce desired behavior, e.g. combos
Behavior	Behavioral contrast	Irrational player behavior
	Blissful productivity	Players work hard within game if actions are meaningful
	Behavioral momentum	Players keep going because they feel what they're doing is valuable
	Urgent optimism	High self-motivation, players want to work on issues instantly with the belief that they will succeed
Game Elements	Quests	Tasks that players have to complete
	Endless games	Never ending sandbox play
	Repeat simple actions	Players enjoy repeating simple in-game actions
	Cascading info theory	Gradually introduce players to game
	Appointments	Fixed in-game appointments to make players return at certain times
	Shell game	Illusion of choice to guide player to desired outcome
	Countdown	Players only get limited amount of time to complete challenge
	Discovery	Giving players opportunity to explore and find new things
Meta	Moral hazard	Actions are devalued by abundance of rewards, too many incentives destroy enjoyment of action
	Epic meaning	Having something great as background story to give meaning to in-game actions

Table 2. Game mechanics organized by category. Not a definitive list, these mechanics are drawn from multiple sources.

achiever and *socializer* types [43] and less by remaining types. Although mechanics related to *cue to action* and *self-efficacy* can be applied to these two gamer types as noted in the previous section, *achievers* and *socializers* are both positively incentivized by *susceptibility*. Because we can assume that a large proportion of the MMORPG players will fall into one of these two types, ***it is appropriate to use mechanics related to susceptibility when designing MMORPGs***. Thus, mechanics such as loss aversion and countdown could be applied in this context.

Consider also the *mastermind*, who enjoys solving puzzles and devising strategies – there are specific types of games that are based on strategic problem solving. *Mastermind* is the only gamer type positively influenced by *severity*, so ***games personalized for masterminds can effectively use mechanics that promote severity***. For example, the negative reward of disincentives, loss aversion, and extinction could work well for this gamer type.

This last example demonstrates how we can personalize for a particular gamer type by using the results of our model and affinity mapping exercise; personalizing design for a specific gamer type is accomplished by following Table 1. The MMORPG example shows how persuasive games could be personalized for a particular game genre, by using our results alongside the established links between the kinds of games enjoyed by each gamer type [43]. There are myriad ways in which persuasive games could be personalized based on our results, and we have included two examples here to demonstrate the relationship between our findings and the corresponding game mechanics.

Applying Health Theories to Persuasive Game Design

Like other persuasive technologies, persuasive games for health aim to change behavior. Therefore, researchers have advocated the use of health theories (which mostly originate from psychology) to inform the design and evaluation of persuasive games. However, many game designers may not have the background to effectively interpret and apply theories in their design. Our work can close this gap by translating the psychology of health behavior to familiar and actionable game mechanics and design approaches.

Our models not only provide persuasive profiles (a list of motivators for the gamer types), they could also be used to guide persuasive games evaluation. For example, if a game aims to evaluate the effect of *self-efficacy* in motivating health behavior, it might be necessary to eliminate all other game mechanics that do not affect self-efficacy. Considering the mapping of health determinants to game mechanics will be useful in deciding the game components to include and evaluate. Moreover, with the help of our models, persuasive game designers can easily evaluate and interpret the effectiveness of their games with respect to the underlying theoretical determinants being manipulated.

Limitations

There are limitations of applying the results of our model to game design mechanics. First, as noted previously, there is no definitive list of game mechanics; we sourced mechanics from multiple resources, but our list is by no means exhaustive or definitive. Second, we mapped the game mechanics into categories using an affinity mapping exercise. These categories are helpful for distilling the results into actionable lessons; however, the process is subject to interpretation. Third, we apply the results of our models at the level of a population (gamer type). As with all population-based personalization, our results will apply to the majority of the population; however, there may be outliers who do not respond in the predicted manner. Fourth, we make our findings actionable by providing examples of how our model results can be incorporated into persuasive game design. This process is not prescriptive of good game design – although our results can provide an advantage in choosing the best persuasive strategy to apply in a persuasive game, applying our findings will not ensure that a game is engaging, motivating, or fun to play. Finally, our work inherited one of the limitations of player typologies – partial membership – although membership is in a single type, a player could be, for example, mostly achiever, but also highly mastermind.

While our work has benefited from the large-scale study of gamers' eating behavior, we cannot assume its validity in other health behavior domains (e.g., smoking cessation) Therefore, our model should be applied with caution in other health behavior domains. However, the underlying principle of mapping determinants to game mechanics and tailoring to gamer types can be applied in any health behavior domain. Although gamer type has been proven as a reliable characteristic for tailoring persuasive game interventions, other characteristics, such as sex, age, and culture (not considered in our study) might moderate the impact of the six HBM's determinants on health behavior.

Future Work

This paper describes a first iteration of a process to bridge theoretical research on what motivates healthy behavior and research on designing persuasive games for health. Our results should be validated in other health behavior domains (e.g., physical activity, smoking cessation) to investigate possible changes in the influence of the determinants. Our results highlighted differences in the interaction between the six determinants and healthy eating behavior for seven gamer types. This suggests a need for a list of persuasive profiles comprised of determinants that motivate various gamer types to adopt healthy behavior. Future studies should therefore examine the impact of the various health behavior theories and associated determinants on each gamer type. Finally, we aim to apply our findings in persuasive game design and evaluate whether a game design that is grounded in both theory and data can motivate behavior change.

CONCLUSION

Persuasive games that are informed by behavioral theories tend to be more successful than those based on intuition. However, there has been little research on how to translate theoretical determinants to game mechanics and how to tailor health determinants to various gamer types. This has resulted in an increasing adoption of a designed-by-intuition, one-size-fit-all approach to persuasive game design. Our work is a step towards providing practical ways of applying and tailoring theoretical determinants of health behavior in persuasive game design. We conducted a cross validation of the influence of the six determinants identified by HBM on healthy eating and developed seven different models of healthy behavior (for each gamer type). Our models revealed some differences between the seven gamer types and we discussed these differences from the perspective of health behavior and persuasive game design. Through our study, we exposed the limitations of the current approaches to persuasive game design, and presented design opportunities for both a one-size-fit-all and a personalized approach to persuasive game design that is grounded in both theory and data.

This study is the first to link research on the psychology of player typologies (as identified by BrainHex) with the psychology of health behavior change (as identified by HBM) to find patterns in gamers' motivation that can inform the choice of game mechanics in designing games to motivate behavior change. Our data-driven and gamer type-relevant design approaches are immediately actionable for designers to build effective persuasive games for motivating health behavior change.

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