

Designing and Evaluating a Drama Manager for Interactive Narrative-Based Games for Health

Langxuan Yin

Northeastern University

yinx@ccs.neu.edu

Abstract. Research in the past twenty years has suggested video games can be an engaging way to promote health behavior change. There have been few studies that compare games for health to standard health interventions, and there has been little research on tailoring games for health to an individual's health behaviors. In this document, I propose to design a drama manager, a game algorithm that generates narrative based on the player's actions and progress in behavior change. I propose to incorporate the drama manager into a visual novel designed to promote exercise behavior change and evaluate the impact of the drama manager on player engagement and behavior change.

1. Introduction

In the past two decades, there has been a dramatic increase in the interest in preventing disability and death through changes in lifestyle, as chronic diseases have taken the place of infectious diseases as leading causes of death. This increased interest in the early detection and prevention of disease has also been stimulated by the aging of the population, increasing health care costs, and data linking individual behaviors to an increased risk of morbidity and mortality [1]. The number of health education and promotion programs delivered using automated information systems is increasing rapidly. These automated interventions have the potential to reach more users, to consistently deliver tailored materials, and to do so effectively and efficiently [2]. However, relatively low user retention rate is one particular challenge that existing health behavior change interventions are faced with [3].

One possible way of increasing retention is by creating engaging health intervention systems. Researchers have started using video games as engaging artifacts of health intervention in the past few years. Some researchers created new games focused specifically on a particular health condition, such as asthma [4, 5], cancer [6], diabetes [7], sexual behavior [8], and stress [9, 10]. Other research is focused on exercise and similar behaviors using existing video games such as *Dance Dance Revolution* [11, 12] and sports games on the Wii Fit [13-15]. However, the majority of these games are not informed by research in health behavior change, have not been evaluated by comparison to standard health care interventions, and do not adapt to the diverse nature of individuals' behavior change psychology. It is therefore difficult to analyze and identify the causal mechanism these games employ in health behavior change.

To address these issues, I aim to design a drama manager—an algorithm that actively provides story structure for an ongoing interactive experience by intervening in the story world in such a way as to help a story to happen [16]—which can be adapted to video games promoting health behavior change. I propose to incorporate a particular health behavior change theory, the Trans-Theoretical Model [17], into the design of the drama manager. I also propose a pilot study and three design studies leading to the design decisions regarding the creation of a video game serving as the research platform of the drama manager, and a summative experiment to evaluate the impact of the drama manager on user engagement and health outcomes.

2. Related Work

2.1 Games for Health

Computerized “serious” games that are designed to promote some positive attitude, knowledge, or behavior change in the user have received an increasing amount of attention in the last few years. The general objective in these efforts is to use the engagement of computer games to increase retention and cognitive engagement of users, and use the game as medium to provide information and behavior change counseling to players. Games designed to change user health behavior have also received a great deal of attention recently, and there is now an annual “Games for Health” conference held in Boston. However, the games that have been developed ignore the decades of work in health behavior change psychology and have been poorly evaluated.

Some early games for health have been empirically evaluated, but the results were not compared to other types of intervention. For example, *Carmen’s Bright IDEAS* is an interactive game designed to teach mothers stress coping strategies [10]. An evaluation study was conducted with sixteen mothers in an eight-week intervention. During the intervention, the mothers interacted with *Carmen’s Bright IDEAS* and clinical research assistants to learn stress coping techniques. Participants’ feedback indicates the story of *Carmen’s Bright IDEAS* is believable and convincing, and that the game helps them memorize and understand the stress coping techniques. However, the results are not compared with a control group [18]. *Life Challenge* is a video game designed to advocate safer sex. In a quasi-experimental evaluation study with more than three hundred participants, it was shown that the game resulted in significant increases in players’ knowledge and self-efficacy in avoiding high-risk sexual behaviors, although these changes were not compared to a control group [8].

Several studies were conducted comparing games for health to other video games. The video game *Packy & Marlon* was designed to improve the self-efficacy, self-care, knowledge and social support of children with diabetes. A six-month intervention study with 59 participants was conducted comparing *Packy & Marlon* to a pinball game. The results show children playing *Packy & Marlon* had significantly higher improvements in social support and self-care than children playing the pinball game, but not in knowledge, self-efficacy, engagement and their number of visits to the doctor [7]. *Re-Mission*, a computer game designed to improve cancer patients’ knowledge and efficacy on cancer, was designed by following the game structure of the computer game *Indiana Jones and the Emperor’s Tomb*. An evaluation study was conducted on 371 children with cancer, where the intervention group was given *Re-Mission* and the control group was given *Indiana Jones and the Emperor’s Tomb*. At the end of the

three-month study, participants playing *Re-Mission* showed a significantly greater increase in cancer-related knowledge and cancer-specific self-efficacy than participants playing *Indiana Jones*. The *Re-Mission* group also maintained significantly higher chemotherapy metabolite levels over time than the *Indiana Jones* group [6].

A few other games have been evaluated in comparison with other types of health intervention, but these evaluations were poorly designed. One of these is *Asthma Control*, a computer game designed to teach children about asthma and its management. A controlled trial study to evaluate the game was conducted with 137 children, where children in the intervention condition received *Asthma Control* and parents in the control condition received asthma knowledge by reading materials. Although children who played the game had a significantly better knowledge gain on asthma, there were no significant differences in hospitalizations across the two groups. Because the control group children were not given direct access to asthma information, the study design made the conveyance of knowledge unfair across the two conditions [4]. Another asthma self-management education game, *Bronkie the Bronchiasaurus*, was compared to an asthma education videotape in an evaluation study with 14 asthma patients ages 8 to 13. Asthma knowledge improved equally for the two groups after a 30-minute study session, and participants playing *Bronkie the Bronchiasaurus* reported higher levels of enjoyment and increased self-efficacy in asthma management. However, participants in the videotape group reported decreased self-efficacy in asthma management. This makes the quality of the videotape, and thus the quality of the study design, questionable [5].

In summary, games created in the research field to improve knowledge and to promote health behavior change have been poorly evaluated. Although many of these games have the potential to retain a user's engagement as much as commercial games do, there is no evidence suggesting these games for health meet the bar for health and medical interventions.

In recent years, commercial games and game platforms have been created to improve players' physical activity. The use of video games in an exercise activity has been referred to as exergaming [19]. Graves et al. conducted a study to compare the energy expenditure among traditional video games, exergaming and real sports. Their study shows children playing the *Wii Sports* bowling, tennis and boxing spend significantly more energy (700-750 kJ per hour) than children playing a sedentary XBOX game (*Project Gotham Racing 3*, 450 kJ per hour), although this amount cannot match the energy expenditure of bowling, tennis, or boxing in real life (800-2410 kJ per hour) [13]. *iAthlete* is a game designed for a dance pad, a device that tracks the player's foot locations on the floor to allow for sprinting and jumping movements. Masek et al. tested the game on fifteen adult participants and measured their heart rate as a percentage of their maximum heart rate. The study shows the participants' average heart rate increased from 58.7% to 67% of their maximum heart rate through a 10 minute session playing *iAthlete*, although statistical significance is not evaluated [11].

More recent studies have demonstrated that exergaming may not lead to health benefits when played at home. For example, Mhurchu et al. compared children playing an exergame with children playing a conventional video game and found that children in the exergame group became more physically active during the 12-week intervention. However, they also played the game less than those in the

conventional video game group [20]. Owens et al. conducted a three-month Wii Fit study in naturalistic settings and found a lack of significance in the participants' change in their health outcomes at the end of the study, and a significant drop in their use of the Wii Fit over time [14]. Graves et al. designed a peripheral device to encourage step-powered gaming on multiple games and found no significant results in their participants' physical activity after a 12-week intervention [21]. Baranowski conducted a 13-week intervention with 84 children, and no statistical evidence was found indicating a difference in physical activity between children given exergames and children given sedentary games to play, although children reported both types of games equally enjoyable [15]. Maloney et al. conducted a comparison study with 60 children during a 28-week period, where the intervention group was given a *Dance Dance Revolution* game and a dance pad at Week 0, and the control group was given the same game and the dance pad at the end of Week 10. The study found no significance between the two groups' physical activity level at the end of Week 10, although a significant difference was discovered between the two groups' sedentary screen time (SST). Children's SST decreased significantly in the intervention group from Week 0 to Week 10 and children's SST increased in the control group [12]. On the other hand, Maddison et al. conducted a study to evaluate the effect of exergaming on children in New Zealand. A total of 330 children were enrolled in the study. Half of the participants (the intervention group) were given a selection of exergames to play over a period of 24 months and the other half (the control group) continued to play their own sedentary games. Results show children's Body Mass Index and weight increase over the 24 months are significantly lower in the intervention group than in the control group. Both groups experienced a reduction in percentage of body fat, but children in the intervention group had significantly higher body fat reduction than children in the control group [22]. Warburton et al. compared participants exercising on a bicycle machine while playing video games on a PS2 system to those exercising on the same bicycle machine without any entertainment. Results of the study indicate that participants who exercised while playing video games attended training approximately 30% more often than those in the control group. Participants in the intervention group also had a significantly higher increase in their aerobic power and a significantly greater reduction in resting systolic blood pressure after a six-week training program [23].

A closer look at the existing research reveals several difficulties the current games for health research faces. First of all, there has been little evidence that existing commercial or research games for health were designed following sound health behavior change theories. This makes it difficult to isolate the causal mechanisms past games have used to change behavior. Also, although a large number of studies have been conducted to test the impact of games for health, most of these studies were conducted on children. How games affect adults' behavior change should also be investigated. In the field of exergaming, three major problems exist. First, the majority of the games focus on getting the player to exercise as soon as they start playing, which may work efficiently with individuals already physically active, but less so with individuals resistant to exercise. This is also difficult to analyze due to the lack of health behavior change theory in both the design of the games and the design of the evaluation experiments. Second, many of the exergames require players to exercise while playing the game, thus the game may possibly act as a distraction, and its potential as a motivating factor has not been systematically explored. Finally, the ultimate goal of games that promote exercise should aim at the

naturalistic setting rather than the laboratory, and these games should aim at promoting health behavior in individuals not committed to regular exercise as well as those already physically active.

2.2 Using Narrative for Health Behavior Change

The Dictionary of Narratology defines narrative as “[t]he representation (as product and process, object and act, structure and structuration) of one or more real or fictive [events] communicated by one, two, or several (more or less overt) [narrators] to one, two, or several (more or less overt) [narratees]” [24]. *The Cambridge Introduction to Narrative* offers a simpler definition: “the representation of an event or a series of events” [25]. In the context of health behavior intervention, narrative may not merely be a representation of events. Polanyi distinguished the concept of “story” from “narrative” by claiming “in recounting a story, a teller describes events which took place in one specific past time world in order to make some sort of point about the world which teller and story recipients share” [26]. This definition, however, constrains the narrative to events that have occurred in the past, ruling out events that are otherwise possible. In narrative-based health interventions, narrative is most likely presented as a story, making a point. In this work, I refer to narrative as a representation of an event or a series of events that have occurred or are possible to occur, which makes a point about the world that the narrator and the audience share.

Researchers have started evaluating the effectiveness of narrative in promoting health behavior change in the past two decades. Houston et al. collected stories from hypertension patients and tested the impact of these stories on reducing blood pressure in patients. 299 patients were randomly assigned to the intervention group, where they were given DVDs containing video stories collected from hypertension patients, or the comparison group, where they received an attention control DVD. The results show significant blood pressure reductions in the intervention group throughout the nine-month study period, and no significant difference in the comparison group [27]. Slater and Rouner conducted a study testing the persuasiveness of different types of message regarding alcohol use. Their findings suggest that evidence with statistical data is more persuasive than narrative-based evidence when the evidence is congruent with the participant’s value, but narrative evidence is more persuasive than statistical evidence when the evidence is incongruent with the participant’s value [28]. Greene and Brinn conducted an experiment comparing the effectiveness of narrative and statistical evidence to persuade college women against tanning-bed use. They found narrative was rated as more realistic while statistical evidence was rated to have higher information value, although no difference was found between the two conditions in mental effort or reflections on the message [29]. Hinyard and Kreuter have conducted thorough research on using narrative as a tool for health behavior change, and suggest that narrative may be viewed as more personal, realistic, believable, and memorable than non-narrative forms of communication [30]. However, Slater et al. have noted that using a non-narrative summary after a narrative communication is considered more effective than using narrative alone [31].

There have been many models of successful storytelling [32]. One particular model explains a frequently used, recurring pattern in successful stories throughout history, including the *Odyssey* and *Star Wars*: the Hero’s Journey [33]. This storytelling model also dovetails with certain theories of health behavior change as will be further explained in Section 3, and thus will play a central role in my research. In the

Hero's Journey, the hero of the story must go through twelve different stages before the story reaches its end. Figure 1 illustrates the process [34]:

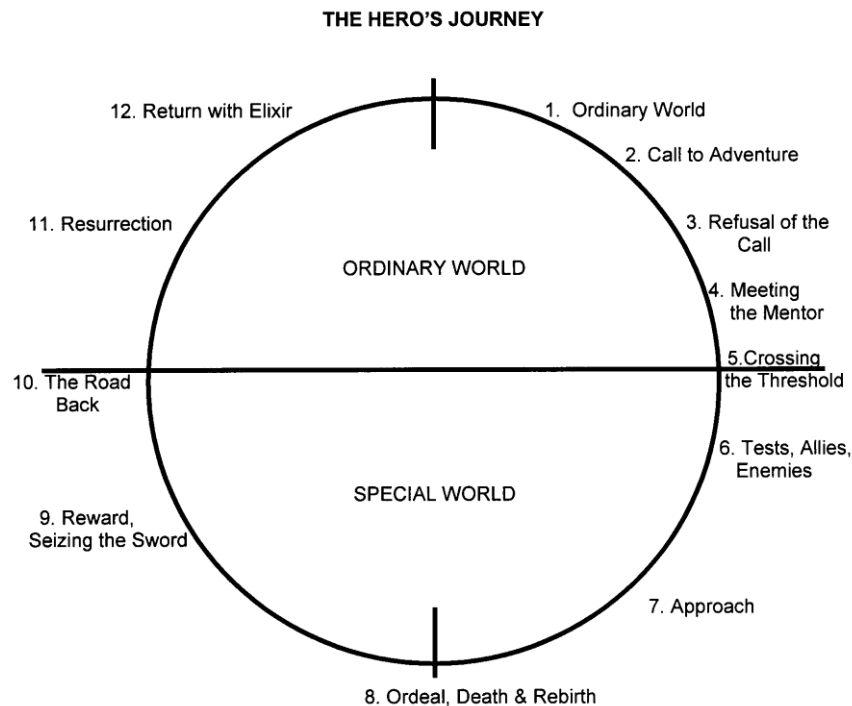


Figure 1. The Hero's Journey

- 1) The Ordinary World: The hero, unaware of his or her fate, is introduced sympathetically so the audience can identify with the situation or dilemma.
- 2) The Call to Adventure: Something changes the hero's situation, so the hero must face the beginning of change.
- 3) Refusal of the Call: The hero feels the fear of the unknown and tries to turn away from the adventure.
- 4) Meeting with the Mentor: The hero comes across a seasoned traveler of the worlds who gives him or her training, equipment or advice.
- 5) Crossing the Threshold: The hero commits to leaving the ordinary world and entering a new world with unfamiliar rules and values.
- 6) Tests, Allies and Enemies: The hero is tested and seeks allies in the new world.
- 7) Approach: The hero and new allies prepare for the major challenge in the new world.
- 8) The Ordeal: The hero enters a central part of the new world and confronts death or his or her worst fear.
- 9) The Reward: The hero seizes the treasure won by his struggles. There is still danger of losing it.
- 10) The Road Back: The hero is driven to leave the new world to ensure the treasure is brought home, but new dangers arise.

- 11) The Resurrection: The hero is severely tested once more on the threshold. The hero experiences another moment of death and rebirth. By the hero's efforts, the forces that were in conflict at the beginning of the story are finally resolved.
- 12) Return with the Elixir: The hero returns home or continues his journey, bearing some element of the treasure capable of transforming the world.

Vogler summarized the Hero's Journey to inform screenwriters, and when doing so, he has suggested that the Hero's Journey not only serves as a model of story writing, it is also a guide to overcoming obstacles in a person's life. Each of these twelve stages also marks the hero's personal growth, referred to as the Hero's Inner Journey [34]. Vogler's statement suggests the Hero's Journey may be particularly valuable when integrated into a narrative aimed at promoting behavior change. I will explore the possibilities of integrating the Hero's Journey to the drama manager of games for health in this work.

2.3 Drama Manager

A drama manager is an algorithm incorporated in a game which generates dynamic narrative content to meet the player's preferences or to give feedback to the player's behaviors in the game. The first drama manager, MOE, was created to support an interactive drama: *Tea for Three* [35]. *Tea for Three* is a short interactive fiction with sixteen critical story phases. Each time the player takes an action, MOE assesses the current state of the interactive drama and a number of possible future scenarios to determine the next move the game should take, which includes letting a character in the story take an action or revealing a clue to the player. MOE's evaluation function will determine the best future scenario that leads to the most dramatically engaging game ending based on the writer's aesthetics. MOE will then generate narrative content according to this best future scenario [35]. Instead of generating content based on the storywriter's aesthetics, the drama manager created for the game *Façade* generates content to increase tension in the story. In *Façade*, the player is required to solve the mystery of the collapsing marriage of his or her two friends. Tension is the degree to which the stress in the couple's marriage is visible, and the degree to which buried problems are coming to the surface. The drama manager in *Façade* generates story content in the form of beats, basic drama units that contain a few turns of dialogue. The drama manager estimates each possible future beat's influence to the story's tension level, and calculates each beat's weight and priority based on the desired tension level in the near future. The drama manager then randomly selects a beat with the highest priority [16]. *Mimesis* is a drama manager created to generate and maintain coherent stories in a 3D virtual world. In particular, *Mimesis* attempts to detect and respond to situations where a user performs an action that seriously conflicts with the storyline. *Mimesis* resolves the conflict by having characters or the game environment perform actions to prevent the user from performing the unexpected action, or by allowing the unexpected user action to take place and restructuring the remaining story plan [36]. PaSSAGE (Player-Specific Story via Automatically Generated Events) is a drama manager that generates story content based on the player's preferences. The player is required to make several choices at the beginning of the story. The PaSSAGE drama manager extracts information from the player's answers to form a player model. The drama manager uses this player model to determine what type of story arc to present to the player [37]. Similarly, the drama manager in the interactive drama *Mirage* adopts a user model to

generate future content and improve engagement. *Mirage* also infers the player's indecisiveness using the amount of time it takes the player to make choices in the game [38].

Several studies have been conducted to assess the user experience when interacting with systems driven by drama managers. *Mirage* has been evaluated using qualitative interviews with five theater and film professionals. After a ten to fifteen minute session playing *Mirage*, participants described characters in *Mirage* as more responsive and alive than typical video games without a drama manager [38]. Knickmeyer and Mateas evaluated *Façade* with eight participants. After up to twenty minutes of game play, six of the eight participants reported they enjoyed the experience and would like to play the game again, even though all players expressed frustration toward the characters when their actions were not coherent due to the dynamic nature of *Façade*'s drama manager [39]. Milam et al. evaluated *Façade* by asking eleven participants to read descriptions of *Façade* and to watch a YouTube video of the game before having them play it. Participants were interviewed after playing the game. In the interview, participants indicated the game progressed too fast, they were not sure whether they have control, and the game did not support certain actions they would like to take [40]. The research findings indicate drama managers are capable of creating enjoyable interactive experiences, but the algorithm has to be carefully designed to maintain coherence and a proper pace.

In health care, computer tailored messages have been shown to be more memorable and persuasive than non-tailored messages [41]. Drama managers have not been used in games for health, but the drama manager's ability to generate personalized content has the potential to make games for health more effective.

2.4 Health Behavior Change

Psychologists in the field of Behavioral Medicine have spent the last several decades developing measures, psychological constructs, and theories that describe how individuals change their health behavior [1]. Studies have demonstrated that health interventions informed by this theory lead to more powerful effects than interventions designed without reference to specific health behavior change theory [42, 43]. The theory that has received the most empirical evidence to date is the Trans-Theoretical Model, an integrated model of leading theories of psychotherapy and behavior change [17]. The Trans-Theoretical Model posits that individuals who successfully change their behavior go through a series of well-defined stages (the "Stages of Change"):

1. **Precontemplation** is the stage in which individuals do not intend to take action in the near term, usually measured as the next six months. Individuals in this stage may be uninformed or under-informed about the consequences of their behavior, or they may have tried to change a number of times and become demoralized about their abilities to change.
2. **Contemplation** is the stage in which individuals intend to change their behaviors in the next six months. Individuals in this stage may be more aware than precontemplators of the pros of changing but are also acutely aware of the cons.
3. **Preparation** is the stage in which individuals intend to take action soon, usually measured as the next month. Individuals in this stage typically have a plan of action, and may already have taken some significant step toward the behavior in the past year.

4. **Action** is the stage in which individuals have made specific, overt modifications in their lifestyles within the past six months.
5. **Maintenance** is the stage in which individuals have made specific, overt modifications in their lifestyles and are working to prevent relapse. Individuals in this stage are less tempted to relapse and are increasingly more confident that they can continue their changes.

The core idea in this theory is that individuals at different stages of change need different things in order to progress to the next stage, thus health messages and interventions should be tailored to an individual's stage to be maximally effective.

Numerous studies have shown the effectiveness of the Trans-Theoretical Model in guiding behavior change interventions. For example, Prochaska et al. compared a smoking cessation intervention to a control group with over 4,000 participants, where participants in the intervention group received intervention materials tailored to their Stage of Change three times within a six-month study period, and participants in the control group received smoking assessments only. Participants in the intervention group had mean point prevalence abstinence of 25.6% and mean prolonged abstinence of 12%, 30%, and 56% greater than the control condition respectively [44]. Bock et al. conducted an intervention to promote physical activity, where the intervention group received feedback reports tailored to their Stages of Change, and the control group received self-help booklets developed to promote physical activity by the American Heart Association. At the conclusion of the six-month study, participants in the intervention group performed nearly twice as much physical activity per week as participants in the control group [45].

The Trans-Theoretical Model also classifies the hundreds of specific behavior change techniques that have been developed into Processes of Change. Processes of change are the covert and overt activities individuals use to progress through stages. Processes of change provide important guides for intervention programs, as they are similar to independent variables that individuals need to apply to move from one Stage of Change to the next. Ten Processes of Change have received the most empirical support to date. For example, Dramatic Relief involves role-playing, grieving, personal testimonies, health risk feedback and media campaigns that can move individuals emotionally, and Stimulus Control involves removing cues for unhealthy habits and adding prompts for healthier alternatives [46].

3. Proposed Work

In my proposed research I will design a drama manager that has the dual goals of maintaining player engagement in an interactive drama while generating narrative content based on the player's Stage of Change and the appropriate Processes of Change for the player. The drama manager will be incorporated into a video game that promotes physical activity. The story of the game will follow the Hero's Journey. Comparing the Trans-Theoretical Model with the Hero's Journey suggests these two models are in alignment. The Hero's Journey may be viewed as a process of behavior change, and each Stage of Change in the Trans-Theoretical Model corresponds to one or more stages in the Hero's Journey model. This can be illustrated by mapping the Trans-Theoretical Model Stages of Change to the twelve stages in the Hero's Inner Journey, as shown in Figure 2.

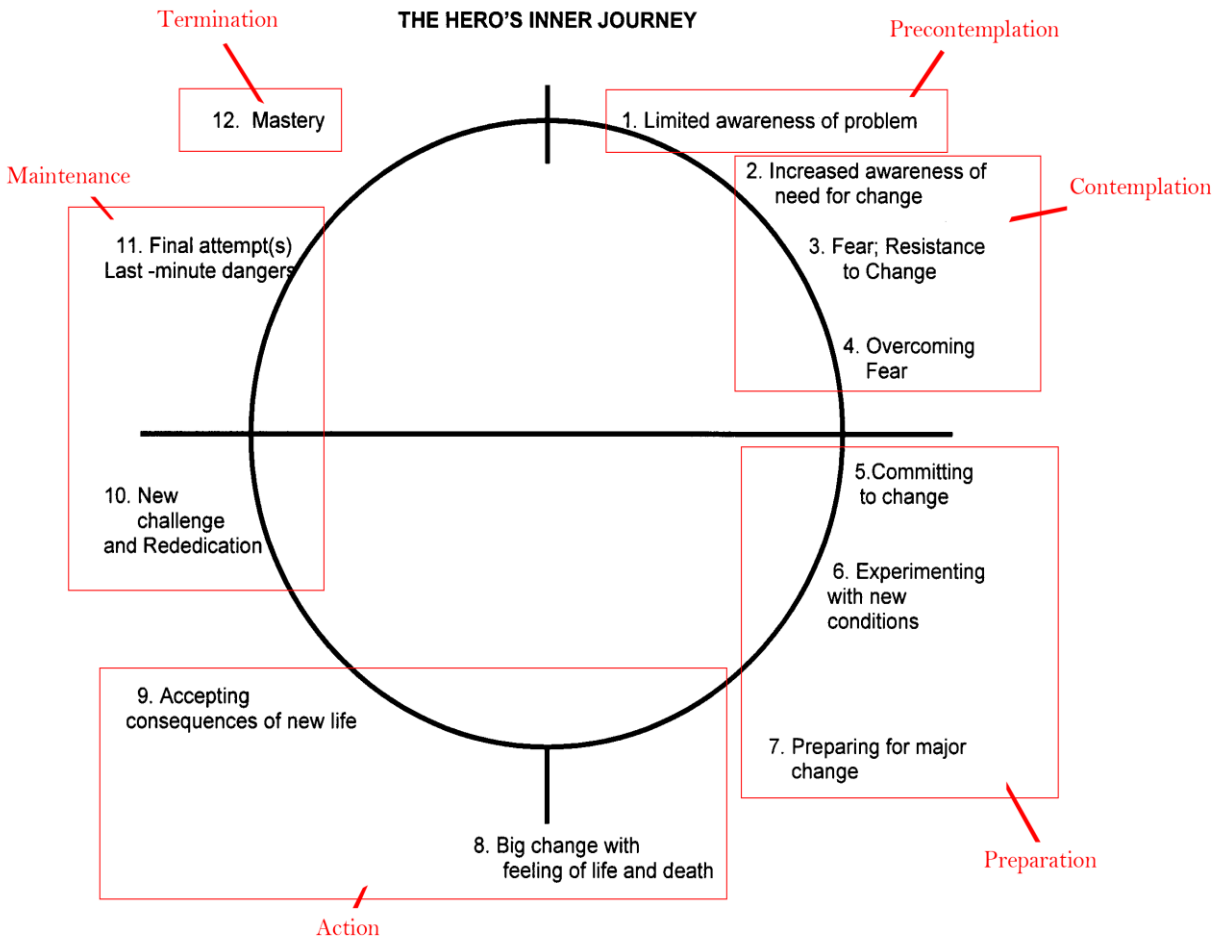


Figure 2. Alignment of Trans-Theoretical Model and Hero's Inner Journey

I propose a strategy in which the drama manager generates narrative within the stages of the Hero's Journey that correspond to the player's stage of change in their real life according to the Trans-Theoretical Model. This strategy will be referred to as Model Synchronization. I propose to evaluate the drama manager's effectiveness in creating engaging interactive experiences and the impact of Model Synchronization on player engagement and health behavior change.

Based on previous research and my own pilot work, I have the following hypotheses that guide my proposed work:

H1. Automated health behavior change interventions that are designed in accordance with validated health behavior change theory result in better outcomes compared to atheoretical interventions. This has already been established by numerous prior studies (e.g. [44, 47-50]), and do not plan to directly test this hypothesis, but take it as an assumption in my work.

H2. Automated health behavior change interventions that are embedded in a game—such as an interactive visual novel—lead to better knowledge and attitude change (via increased cognitive

engagement) and better long-term retention compared to automated interventions that are not embedded in games. I have preliminary evidence for this hypothesis through a pilot study I recently completed (described in Section 3.1).

H3. Automated health behavior change interventions embedded in narrative games are significantly more effective when the behavior change activities the user is asked to perform are both aligned with their stage of change, and the progression of their character's status in the game. This is the primary hypothesis I will be testing in my planned research.

3.1 Testing H2: Completed Pilot Study on Engagement with Games for Health

As a first step to testing my hypotheses, I created a visual novel game with a story crafted to improve the self-efficacy. Visual novel is a genre of games similar to interactive fiction [51], but with the addition of static images and animations to help players visualize the story being told. Existing drama managers have taken on the forms of interactive fiction [35] and interactive drama [16], which are similar forms to visual novel. I evaluated player engagement to the visual novel and the game's impact on the player's self-efficacy, the situation-specific confidence that people can cope with high-risk situations without relapsing to their former behaviors, a core construct of the Trans-Theoretical Model [1, 52]. Figure 3 shows a snapshot of the visual novel.

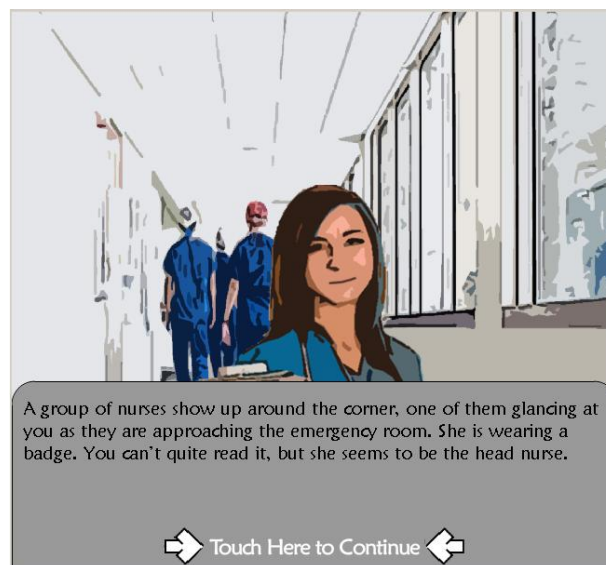


Figure 3. A snapshot of the visual novel for testing H2

Game Design

The game that I designed, *The Time Mage*, takes on the form of a visual novel. The game features a story where the player is required to take care of a hospital patient under a heart attack. During game play, the player is faced with the challenge that the patient will be given an incorrect procedure. In order to complete the game, the player has to demand in a proper way that the correct procedure be performed. Studies have shown interventions where an individual is required to take responsibility for another individual or an object can raise the individual's self-efficacy [53, 54].

Experiment Design

The pilot study was conducted to compare the visual novel with other types of health intervention in terms of player engagement and change in self-efficacy. The experiment was a between-subject design, and had three conditions: 1) a Control condition where the participant was asked to read through the Patient Rights and Responsibilities of Boston Medical Center (a paper pamphlet) [55]; 2) a Novel condition where the participant was asked to go through *The Time Mage* in the form of a novel on a computer, with no audio or artwork, where the participant had no control over the story, and 3) a Game condition where the participant was presented with *The Time Mage* in the visual novel form. The script in the Novel condition followed the longest path of the game storyline. The game play in the Game condition lasted 10-20 minutes.

Dependent variables included the participant's engagement in the intervention and their change in self-efficacy. Engagement was measured by flow, an optimal experience that is intrinsically rewarding, or autotelic [56, 57]. The English version of the Generalized Self-Efficacy Scale [58] was modified to measure 1) the participant's confidence in taking care of themselves during a hospital stay as well as 2) their confidence in taking care of a family or friend during their hospital stay. These two questionnaires were administered both before and after the intervention in every condition to calculate change in self-efficacy.

Results

Participants were recruited via fliers and advertisements on the internet. Participants were enrolled if they were 18 years old or older, speak and read English, and have been hospitalized before or have accompanied someone who was hospitalized. Thirty-six participants were recruited for the study.

An ANOVA is performed using the condition as an independent variable and the change in self-efficacy (post-score minus pre-score) as a dependent variable. The test showed no significance, $F(2, 33) = 0.319$, n.s. I tested the Pearson correlation between composite flow score and change in self-efficacy. The test also showed no significance, $r=.108$, n.s. I also analyzed the data with an ANCOVA, using the study condition as an independent variable, the composite flow score as a covariate, and the change in self-efficacy as a dependent variable. The analysis showed study condition had a significant impact on the change of self-efficacy, $F(2, 33) = 6.865$, $p = .004$. Study condition and flow score also had a significant interaction effect on the change in self-efficacy, $F(2, 33) = 6.886$, $p = .003$. Figure 4 illustrates this effect. Other results can be found in my paper [59].

Discussion

Results of this study do not show significant differences in the visual novel's ability to engage players and to increase their self-efficacy compared to a standard hospital pamphlet and a novel, but the study demonstrates a correlation between a visual novel player's engagement with the game and self-efficacy change. This correlation indicates that improving the player's engagement with a visual novel may possibly improve their self-efficacy, which may positively influence the player's transition from one stage of change to the next. Therefore, H2 is partially supported.

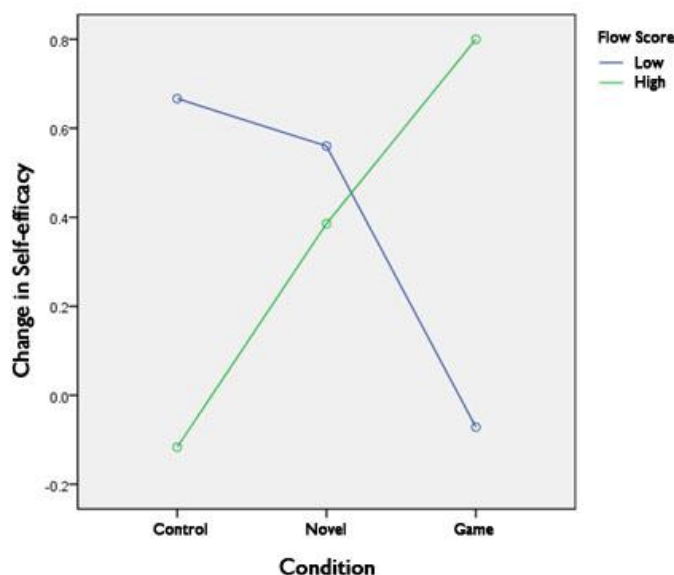


Figure 4. Interaction effect of study condition and flow on change of self-efficacy, $F(2, 33) = 6.886$, $p = .003$. Flow state score is split at the median and categorized into High and Low for this plot.

3.2 Development of a Research Platform to Test H3

To design an engaging visual novel that promotes physical activity as a research platform to test H3, I made several design choices and have raised three design questions. I will discuss my design choices, and propose three design studies to answer the design questions.

3.2.1 Design Choices

The visual novel will feature a narrative structurally in line with the Hero's Journey. The player will use a mouse and a keyboard to play the game. The player will be assigned homework throughout the game to promote their behavior change in physical activity. The player will be given a pedometer and will connect it to the computer to upload physical activity data. The player will be expected to spend 20 to 40 minutes each day playing the game, during the two to four week study. Besides these premises, I have made the following design choices.

Player Input

Player input occurs when the player character has to make a choice. Player input is an important way for the player to interact with the game world. Commercial games have presented many different approaches to this interaction. Since the early days of visual novels, a multiple choice dialogue box has been the most prevalent approach to player input. In the game *Tokimeki Memorial*, the player makes choices when conversing with non-player characters (NPCs). These choices will positively or negatively influence his or her relationships with the NPCs and will determine which path of the story the player character takes. In later games including *Sakura Wars* and *The Walking Dead*, the player is given a limited amount of time to make a choice, adding tension to the game play. Another type of player input

has emerged in recent years, wherein the player is given an abstract response representing the meaning of the statement or action they are going to make or take, such as in *The Sims*. In *Dragon Age: Origins 2*, the player's choices include the statement their character will say accompanied by the emotion associated with these choices.

Sali et al. studied three different types of player choice systems: sentence selection, as in most of the games; abstract response, as in *The Sims*; and natural language understanding. The results show abstract responses are the least challenging and give the player the most control. However, sentence selection, being relatively challenging and giving the player a relative sense of control, makes the story most enjoyable and engaging [60]. Considering these results, the game design in this thesis will feature sentence selection to retain the player's engagement. Player choices will also be timed in urgent situations to help the player concentrate on game play.

Graphic Style

Early visual novels employed static pixel art due to limitations in technology. Recent technical advancements have brought new forms of graphic styles to visual novels. *Heavy Rain*, for example, features a full 3D interactive space. *The Walking Dead* applies cartoon rendering to its 3D environment. Despite technical advancements, many visual novels still employ a 2D style. The 2012 game *Katana Shoujo* uses static images throughout the story. The *Ace Attorney* series uses static images and occasional simple animations. These range from a two-frame animation of a lawyer angrily smashing the table to several frames of animation depicting a witness sweating over a flawed statement. *Dark Parables 4: The Red Riding Hood Sisters* uses static images and 2D animations throughout the game to illustrate combat scenes and increase tension, whereas *Fate / Stay Night* achieves a similar type of tension through the use of motion techniques on static images (such as making a static picture shake up and down on the screen).

I will employ a 2D design in this game, using static images for the majority of the game, but may use animations when appropriate. This choice is mainly to reduce financial spending and time consumption to focus on the experimental phase of this thesis.

Emotional Engagement

One way of engaging players to a video game is to create an emotionally engaging story. Emotional engagement has rarely been explored in games for health. I will employ emotional engagement techniques in the visual novel to enhance player engagement. Freeman has summarized his screenwriting and game writing experiences into a methodology that improves the player's emotional engagement, called *Emotioneering* [61]. In this thesis, I will employ simple techniques in *Emotioneering* to create interesting and deep NPC characters and dialogue. Depending on the narrative and the time allowed to complete the game development, NPC growth and NPC-player relationship techniques may be used.

Homework

Processes of change in the Trans-Theoretical Model indicate that individuals need to engage in a variety of activities to change a behavior [46]. Previous studies have shown that setting exercise goals in a computer-based health intervention helps increase and maintain an individual's physical activity [62, 63]. In this work, the visual novel will set exercise goals for players in the Action and Maintenance Stages of Change. Players will be asked to wear their pedometer and upload their exercise data to the game on a daily basis. During the Precontemplation, Contemplation and Preparation stages, homework will include tasks the player has to achieve by visiting certain websites, experimenting by themselves, or asking for help from friends or family members. Test questions will be incorporated in the visual novel to assess the player's performance in their homework.

Regardless of the player's performance in their homework, the game's story will proceed as planned. If the player succeeds in their homework, the game should present the player character with an in-game reward to facilitate positive reinforcement. These rewards may include an accelerated progress through routine game tasks, an upgrade to the player character's ability or gadget, or a revelation of additional information that may be useful for later phases of the game.

The following section describes three design studies drafted to evaluate other design choices. These design studies require a small number of participants. Instead of looking for significant results, these studies only aim to discover correlations and trends.

3.2.2 Design Studies

Design Study 1: Player Character Presentation and Action Style

Commercial visual novels employ a range of choices regarding the presentation of the player character. *Heavy Rain* allows the player to see a 3D model of their character from any angle. Earlier visual novels such as *Dark Parables* and *Myst* let the players view the world through their characters' eyes, so the player does not see what their character looks like. This design feature allows a character's gender and appearance to be ambiguous. *Tokimeki Memorial* employs a style in between, showing the male protagonist occasionally, with his facial features and expressions ignored. *Ace Attorney* employs both styles, presenting the world through the player character's eyes during the phase where the player character investigates a crime scene, and portrays his upper body when the player character defends his client in the court. In *Ace Attorney*, the player character's facial features and expressions are fully depicted to illustrate the protagonist's character and his involvement in the story.

Fox and Bailenson have discovered that seeing a virtual representation of the physical self (VRS) exercising helps individuals improve their physical activity significantly more than seeing a virtual representation of an other (VRO) [64]. This indicates that showing a character imitating the player during the game may be more efficient in promoting player physical activity. However, Fox and Bailenson's findings were discovered in a virtual reality setting. In this design study, I will compare a visual novel that presents the player character to a visual novel that does not present the player character in terms of player engagement and change in self-efficacy.

In this study, I will also test whether the visual novel should allow the player to take actions other than making dialogue choices during game play. Many visual novels do not require player input beyond multiple choices. This type of game is focused on letting the player experience different perspectives of the story to solve a mystery. Other visual novels engage the player by requiring the player to click the mouse or press certain keys or key combinations. These actions and action sequences create moments that require the player's concentration. For example, *Heavy Rain* contains several chase scenes and fighting scenes, where the player is required to press a few buttons in order within a short time limit, and a few wrong moves can result in one of the four main characters' death. In *The Walking Dead*, zombies can attack the player at any time; when this happens, the player has to hold or press a certain key or place the mouse cursor at a certain location on the screen within a short time frame. I hypothesize that an action style similar to that in *The Walking Dead* will work effectively for this game. This action style adds tension to the game and has the potential to increase player engagement, but it does not require a high level of skill or a long time of practice. Players in this game are not likely to fail an action multiple times, which causes frustration. This hypothesis needs to be tested. The addition of action challenges the player, and succeeding may lead to the player's increase in self-efficacy.

Experimental Design

This experiment is a 2 (no player character presentation vs. player character presented as an ambiguous looking protagonist distinguishable by gender) by 3 (no action vs. *The Walking Dead* action style vs. *Heavy Rain* action style) within-subject design. Six 5-minute game play sessions will be created to cover all six conditions. Participant will go through all six game sessions, but the order by which the six sessions are presented will be counter-balanced. Participants will rate their engagement with the game after each session. Pre-test and post-test scores of self-efficacy will be collected at the beginning and again at the end of the study. Participants will be asked to rank the six sessions in the order of the amount of self-efficacy change that each session invoked.

Design Study 2: Dual-Character Storytelling

Framing device is a literary technique where a story is narrated by a character or in other means within the story being told to the audience [65]. A particular type of framing device is a structure where a character experiences another character's story. This particular structure has been used for educational purposes. The 1991 novel *Sophie's World* used this type of framing device, where the story appears to be about a teenage girl named Sophie in the beginning, but the reader will later discover Sophie is merely a character in a book written by another character, Albert Knag as a birthday present to his daughter Hilde. In the story, Hilde's understanding of philosophy increases in synch with Sophie's understanding of philosophy. During this process, the reader and Hilde together experience Sophie's story, and gain expertise in philosophy at the same pace. I call this particular type of Framing Device **Dual-Character Storytelling**.

In Dual-Character Storytelling, two layers of stories exist, featuring two different characters: an inner layer where the majority of the story occurs, and an outer layer that has a higher level of connection with the audience. I hypothesize that by having the player and an outer-layer character go through a

similar growth path, player engagement and behavior change can be improved compared to a single layer story. For this reason, I hypothesize homework on health behavior change should be given to the player through the outer layer. Before testing this hypothesis, an important question needs to be considered: Will the player's preference or lack of preference toward the homework be the result of the difference between inner layer and outer layer stories? In particular, the inner layer and outer layer stories will differ in terms of the story setting, characters' personalities and relationships, the player character's abilities and situation. This may create personal biases that may influence the effects of homework.

Experimental Design

In this experiment, I will design one inner layer story based on a classic or popular story from a novel, play, movie or video game, to ensure the quality of the story. I will also design three pieces of outer-layer stories in a variety of historical or futuristic settings, using characters portrayed similarly but with different personalities and relationships, and giving the player character different abilities and putting them in different situations. These outer layer story pieces will be combined with the inner layer story to create mixed layer story pieces. The inner layer story piece and the three mixed layer stories will be tested in a within-subject study. The inner layer story session will last less than 10 minutes. In each mixed layer story session, the outer layer story will be presented in the beginning to introduce the inner layer story, and again in the end to conclude the entire game. Each of these conditions will last less than 15 minutes. Participants will be asked to rate their engagement with the game after each session. The mixed-layer story rated closest to the inner-layer story will be extended to create the final game.

Design Study 3: Homework Layer and Orientation

In a Dual-Character Storytelling structure, homework from the Trans-Theoretical Model can be given to the player in various ways. As mentioned in Design Study 2, I hypothesize the player will share a growth experience with the outer layer character, and giving homework to the player through the outer layer will be more engaging and effective in behavior change compared to giving homework through the inner layer. This needs to be tested. In the story, homework can be either presented to the player or to the player character. Whether this choice will make a difference in player engagement and behavior change is a research question that needs to be answered.

Experimental Design

The experiment will be a 2 (homework in inner layer vs. homework in outer layer) by 2 (homework presented to player vs. homework presented to player character) between-subject design. A short game containing an inner layer story and an outer layer story will be created. The outer layer character will express his or her concerns about physical activity. Homework on exercise will be given during the game play. Each participant will be randomly assigned to one of the following four conditions:

- 1) Homework is given in the inner layer story, directed towards the player.
- 2) Homework is given in the inner layer story, directed towards the inner-layer character.
- 3) Homework is given in the outer layer story, directed towards the player.

- 4) Homework is given in the outer layer story, directed towards the outer-layer character.

Each session will take 10 to 20 minutes to finish. Participants will be asked to rate their engagement with the game after the session. Pre-test and post-test scores of participants' self-efficacy in exercise behavior change will also be collected to calculate change in self-efficacy.

3.2.3 Drama Manager Development

Following the Hero's Journey model, a complete story is divided into twelve stages. I divide each stage further into multiple plot segments. Each plot segment will include one particular scene, in which one or more characters complete a few turns of dialogue regarding a single topic or one or more characters complete a few actions to achieve a single goal. A plot segment that is necessary to push the story forward is equivalent to a kernel, defined as a part of the story that is logically essential to the narrative action and cannot be eliminated without destroying its causal-chronological coherence [24]. A satellite, on the other hand, is a minor plot segment that is not logically essential to the narrative action, and their elimination does not destroy its causal-chronological coherence: rather than constituting crucial nodes in the action, they fill in the narrative space between these nodes [24]. The plot segment is the basic narrative unit in my drama manager. The game designer should create a story in the form of kernels and satellites and use these plot segments as input to the drama manager.

The drama manager in this work has three major roles. First, the drama manager determines how much time the game allocates to each stage of the Hero's Journey. The game designer should determine what proportion of game play each stage of the Hero's Journey should occupy in the entire game. The game designer should also determine the expected total number of hours of game play (Total Time) and the minimum number of hours the player has to spend in each stage (Min Time). The drama manager uses Model Synchronization to identify the Hero's Journey stages that correspond to the Stages of Change that the player has already gone through at the beginning of the game (Past Story Stages). The drama manager will allocate Min Time to each Past Story Stage. The drama manager calculates the remaining number of hours to allocate, which is $(\text{Total Time} - (\text{Min Time} * \text{number of Past Story Stages}))$. The drama manager scales the remaining Hero's Journey stages (Primary Story Stages) based on their proportion in the game play. If the total play time does not allow a player to progress through all the remaining Stages of Change, the drama manager reserves Min Time for any Primary Story Stage at the end of the game and ends the current Hero's Journey stage when the amount of time equal to $(\text{Min Time} * \text{number of remaining Primary Story Stages})$ is left. The second role of the drama manager is to select the kernels presented to the player. Each kernel may have several different implementations. These implementations vary in length, appropriateness for the player's Stage of Change, and appropriateness for the player's Processes of Change. Kernels will be selected based on the number of hours allocated to the current Hero's Journey stage and its appropriateness for the player. Lastly, the drama manager selects satellites to be presented to the player. In my drama manager, each satellite has a variety of properties:

- 1) Preconditions: Conditions that have to be fulfilled for the segment to be considered as the next story piece by the drama manager.
- 2) Connections: Characters, objects, or clues introduced by previous kernels and satellites.

- 3) Behavior Change Data: Information regarding which Stages of Change this satellite is most appropriate for and which Processes of Change this satellite addresses.

Similar to the Beat in *Façade*, a satellite in my drama manager is also assigned a weight and a priority [16]. As in *Façade*, weight and priority are also used to determine whether a satellite will be considered or chosen to be the next story piece in my drama manager. However, in my work, priority will be calculated by comparing the satellite’s Behavior Change Data with the player’s current Stage of Change and Processes of Change. Weight will be derived from the satellite’s Connections.

The drama manager picks each satellite whose preconditions have been met and calculates its priority and weight. During this process, the drama manager categorizes satellites into several priority tiers. The drama manager then selects a satellite through a weighted randomization process in the highest priority tier.

3.3 Summative Study Testing H3: Model Synchronization

In this experiment, I will evaluate the drama manager’s effectiveness in engaging players with the visual novel and in promoting player exercise behavior change. One particular question I must answer is whether Model Synchronization makes the game experience more engaging and beneficial to the player’s behavior change.

Experimental Design

The drama manager can be modified in multiple ways to break Model Synchronization. As mentioned in Section 3.3, in Model Synchronization, the weight of the narrative is given to Primary Story Stages, and time allocated to Past Story Stages is minimized. In this study, I will create a Model-Desynchronization condition, where the Primary Story Stages and Past Story Stages will differ from Model Synchronization. This will cause the user to receive the same type of homework they would in the Model Synchronization condition, but the narrative will progress in a different pattern. Table 1 demonstrates the Primary Story Stages in each condition, based on each player’s current Stage of Change, using numbers assigned to each stage of the Hero’s Journey in Section 2.2.

Study Condition Player Stage of Change	Model-Synchronization	Model-Desynchronization
Precontemplation	1-12	5-12
Contemplation	2-12	8-12
Preparation	5-12	10-12
Action	8-12	1-12
Maintenance	10-12	2-12

Table 1. Primary Story Stages for the two intervention groups based on participant Stage of Change

The Model-Desynchronization group will receive the same type of health intervention as the Model-Synchronization group, and will experience an equally engaging visual novel as participants in the Model-Synchronization group. The only difference between the two groups is which part of the narrative they will experience.

This experiment will be conducted outside the lab. Participants will be randomly assigned to one of three conditions: Model-Synchronization, Model-Desynchronization, and Control. Participants in Model-Synchronization and Model-Desynchronization will receive the visual novel, but the drama manager in their game will function differently. Participants will be asked to play the game on a daily basis. The game will limit the participant's game play to 20 to 40 minutes per day. Participants in the Control group will not receive the visual novel. All participants will be given a pedometer to record their walking steps. The study will last two to four weeks. Participants' engagement with the game will be measured by tracking the frequency of their game play. Participants' exercise self-efficacy and Stage of Change will be assessed using an exercise self-efficacy questionnaire [66-68] at the beginning and the end of the study to calculate change scores. Participants' walking steps data will be collected from their daily uploads (except in the Control condition) and at the end of the study.

Hypotheses

The following are specific hypotheses of H3 that I will test:

Hypothesis H3.1: Participants in the Model-Synchronization condition will play the visual novel significantly more often compared to participants in the Model-Desynchronization condition.

Hypothesis H3.2: Participants in the Model-Synchronization condition will progress significantly more in their exercise behavior change through the study compared to users in the other two conditions, as measured by their Stage of Change before and after the study.

Hypothesis H3.3: Participants in the Model-Synchronization condition will have a significantly higher increase in exercise self-efficacy through the study compared to participants in the other two conditions.

Hypothesis H3.4: Participants in the Model-Synchronization condition will have a significantly higher increase in their daily walking steps compared to participants in the other two conditions throughout the study.

4. Research Timeline

My research plan is explained in Table 2.

Time	Milestone
July 2013	A visual novel prototype will be developed, including a number of variants to be used for Design Studies 1-3. Different design tools and engines will be explored.
December 2013	Complete Design Studies 1-3.
June 2014	Design Studies 1-3 results will be analyzed. Publications on the design studies will be submitted. Game design will be modified. Drama manager will be developed. Narrative and art will be created for the final game.
October 2014	Summative Study completed.
December 2014	Defense.

Table 2. Research milestones and deadlines.

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