The Construction and Evaluation of a Design Framework for Narrative Games for Health

Langxuan Yin

NORTHEASTERN UNIVERSITY
GRADUATE SCHOOL OF COMPUTER SCIENCE
Ph.D. THESIS APPROVAL FORM

THESIS TITLE:
The Construction and Evaluation of a Design Framework for Narrative Games for Health

AUTHOR: Langxuan Yin

Ph.D. Thesis Approved to complete all degree requirements for the Ph.D. Degree in Computer Science.

Thesis Advisor	*Date* 5/5/15
Thesis Reader	*Date* 1 MAY 2015
Thesis Reader	*Date* 1 May 2015
Thesis Reader	*Date* 1 May 2015

GRADUATE SCHOOL APPROVAL:

Director, Graduate School	*Date* 5/5/15

COPY RECEIVED IN GRADUATE SCHOOL OFFICE:

Recipient's Signature	*Date* 5/5/2015

Distribution: Once completed, this form should be scanned and attached to the front of the electronic dissertation document (page 1). An electronic version of the document can then be uploaded to the Northeastern University-UMI website.

Abstract

A larger number of games for health were developed over the past two decades to provide an engaging way of health care and behavior change intervention. However, many problems with the design of these games, as well as with the methodologies used to evaluate them emerged: the games were generally designed without the consultation or direct involvement of a professional game designer, and created without the guidance of a proper game design framework; the health messages delivered in the games were mostly simple and knowledge-oriented and not crafted based on theories from behavioral medicine; and the evaluation studies were also poorly designed.

To solve these problems, I define the DraGuNa (Drama-Guided Narrative Health Game) framework, a methodology that uses drama theory and sound principles from behavioral medicine to guide games for health design to solve the current problems in games for health. The dissertation introduces a methodology of game design, specifically developed for games for health, which addresses two key constructs: engagement – ensuring users stick with the game for the duration of the intervention; and adherence – ensuring users perform those actions in the game hypothesized by behavioral medicine theories to lead to health behavior change. The dissertation also provides a methodology to develop interactive narrative-based games based on existing story media, which also suggests a new path of research for the intelligent narrative community. Finally, the dissertation describes an experimental framework for testing the effects of a game on the two fundamental dimensions of player involvement in the intervention – engagement and adherence – and tests the relative contributions of each on health outcomes.

Acknowledgements

First and foremost, I owe this dissertation to my parents. The high hopes that my parents had of me and the strong sense of discipline that I grew up to embrace created the scholar that I am today.

I'd like to thank my advisor, Timothy Bickmore, for the guidance he had given me throughout the long years of the Ph.D. program. I also want to thank former and current members of the Relational Agents Group, especially Zach Berwaldt, Juan Fernandez, Zhe Zhang, Lin Shi, Ha Trinh, Elizabeth Bates, Kathleen Totzke, for helping me conquering the challenges during the development of my dissertation and in my work as a research assistant. Thanks also go to two Ph.D.'s who graduated from my lab, Daniel Schulman and Laura Pfeifer Vardoulakis, for setting high scholarly standards and showing me what seemed impossible.

I owe special thanks to Lazlo Ring, Angelo Cafaro, Joshua Bolduc, and Luke Farrer, for they are incredible friends, who gave me inspirations, wisdom and support when most needed, and, especially for someone like me, with no family and no relative around, a sense that I am not forsaken.

I want to thank all of my friends who have offered me a job or referred me to their employers towards the end of the Ph.D. program. Securing a job offer helped me focus on my dissertation in the last two months of my degree.

I must also thank my girlfriend Danhui Chu, for helping me through the darkest page of my life, keeping me concentrated on what is the most important, and encouraging me to rediscover the patience and tranquility in me that I thought for a time lost.

Finally, I should mention the Count of Monte Cristo by Alexandre Dumas, for the book taught me something that made the completion of this dissertation possible, that is, the essence of all human wisdom: Wait and Hope.

Contents

Chapter 1. Introduction

The leading cause of death in the United States and in the world today is chronic disease (Yach et al. 2004), and lifestyle health behaviors—such as physical activity, diet, and smoking—are the most prominent contributors to these diseases and other causes of death (Mokdad et al. 2004, Mokdad et al. 2005, Schroeder 2007). Changing lifestyle health behaviors is a difficult, long-term process and often requires education regarding the behavior and help from counselors. However, not everyone has access to counselors at the time and place they are needed. To address this, there have been many attempts to develop computerized health behavior change interventions, which offer wide accessibility and low cost relative to human counselors. However, several studies have shown that these interventions suffer from disuse and automated longitudinal interventions suffer from high attrition rates (Bickmore et al. 2009, Vardoulakis 2013). Computer games may solve these problems by providing a particularly engaging medium that keep users' attention for extended periods of time.

The research on the use of game elements to promote health behavior change began two decades ago. Studies that aimed to use video games to improve children's diabetes management (Brown et al. 1997) and to increase a player's self-efficacy in safe sex negotiations (Thomas et al. 1997) date back to the 1990s. However, this area of research blossomed into its own field in the early 21st century, when the concept of "games for health" became an independently important area of research. The establishment of the Games for Health Conference in 2004, the release of the Wii Sports games in 2006, and the launch of the Games for Health journal in 2012 brought public attention to the term, and the amount of research and investment in this new discipline of science increased steadily.

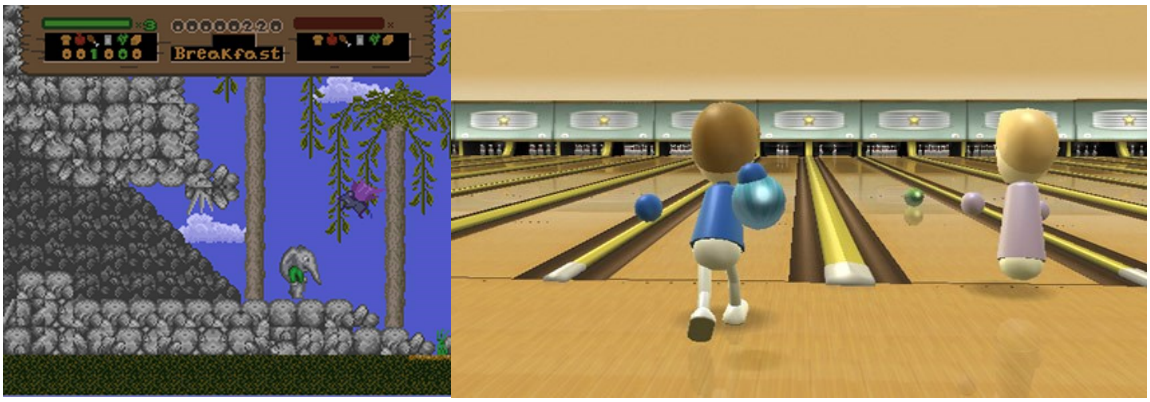

Figure 1.1. Earlier games for health: Packy & Marlon (left), a game that aims to improve diabetes management, and Wii Sports (right), an active game that promotes physical activity.

As a larger number of games for health were developed over the past two decades, studies were conducted to evaluate these games, and a vast majority of them yielded positive results. However, many problems with the design of these games, as well as with the methodologies used to evaluate them emerged: the games were generally designed without the consultation or direct involvement of a professional game designer, and created without the guidance of a proper game design framework; the health messages delivered in the games were mostly simple and knowledge-oriented and not crafted based on theories from behavioral medicine; and the evaluation studies were also poorly designed (Kharrazi et al. 2012). In recent years, research on games to promote physical activity in naturalistic settings suggest that these games are not effective in changing players' physical activity behavior over the long term (Baranowski et al. 2012). The research in this area will be discussed further in Chapter 3.

Another recent trend is the use of game elements in many kinds of serious applications to engage users in otherwise uninteresting tasks: so-called "gamification." Many applications of games for health can be considered a type of gamification: using game mechanics and game-like storytelling to engage users in behavior change or learning health-related knowledge. There has been much debate on whether gamification is an effective technique, or whether it actually hurts consumers as well as businesses (Bogost 2011). This damage is often caused by a shallow understanding of

game mechanics or inappropriate use of game elements that encourage unintended behaviors (Groh 2012).

It is the state of the current games for health research that motivated this dissertation. In this work, I define the DraGuNa framework, a methodology that uses drama theory and sound principles from behavioral medicine to guide games for health design. The framework is general enough to fit any behavior change program using a unified theoretical framework. In terms of game design, it encourages the use of rich narrative to engage the player and is rooted in widely-accepted drama theory and emerging interactive drama technologies. This dissertation also provides as an example a prototype game created using the DraGuNa framework and existing story media: Adventures of the Atomic Submarine. Through the discussion of a study designed to evaluate this prototype game, I also propose a better way of designing evaluation studies for games for health.

Throughout this dissertation, I have used physical activity promotion as my example health behavior of interest. While the techniques and theories I describe are applicable to most health behaviors, physical activity is especially important for its positive impacts on almost every system in the body, its universality (almost everyone should perform some physical activity (Pate et al. 1995)), and the existence of many validated measures to evaluate intervention outcomes.

The contributions of this dissertation are three-fold. First, the dissertation introduces a methodology of game design, specifically developed for games for health, which addresses two key constructs: engagement – ensuring users stick with the game for the duration of the intervention; and adherence – ensuring users perform those actions in the game hypothesized by behavioral medicine theories to lead to health behavior change. Second, it provides a methodology to develop interactive narrative-based games based on existing story media, which is important for several reasons. Finally, the dissertation provides an experimental framework for testing the effects of a game on the two fundamental dimensions of player involvement in the intervention – engagement and adherence – and tests the relative contributions of each on health outcomes.

The rest of this dissertation is organized as follows: Chapter 2 discusses the health behavior change theory that is used as the foundation of the DraGuNa framework. Chapter 3 discusses related work, including research in games for health, drama theory, and developments in interactive drama. Chapter 4 discusses the DraGuNa framework and its two facets: engagement and adherence. The chapter explains theories and techniques that can be used to enhance player engagement to a game and maintain a user's adherence to a health intervention, as well as an intelligent narrative system to facilitate tailoring and reinforcement. Chapter 5 describes Adventures of the Atomic Submarine, a prototype game promoting physical activity developed using the DraGuNa framework, covering the story used in the game, which was adapted from a 1950s comic book, and the technical details of the game's implementation. Chapter 6 explains an evaluation study that compares the prototype game to alternative interventions that promote physical activity. Chapter 7 discusses the results from the study as well as possible improvements to the game. Chapter 8 reviews the findings in this dissertation and explores the future directions to extending the DraGuNa framework and strengthening games for health research.

Chapter 2. 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 (Glanz et al. 2008). 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 (Ammerman et al. 2002, Legler et al. 2002). For example, the Health Belief Model (HBM) was developed to explain why people accept preventive health services and why they do or do not adhere to other kinds of health care regimens (Hochbaum 1958, Rosenstock 1974); the Theory of Reasoned Action (TRA) and the Theory of Planned Behavior (TPB) attempt to chart the rational decision-making process behind behavioral intentions and behavior change, suggesting that attitude towards a behavior, subjective norm, and perceived control influence the outcomes of behavior change (Ajzen 1991, Ajzen and Fishbein 1980, Fishbein and Ajzen 1975); the Self-Determination Theory (SDT) indicates that three psychological needs must be fulfilled for optimal change to occur: competence (the urge to control outcomes), autonomy (the urge to be the master of one's life and to act in consistency with one's will), and relatedness (the want to interact and be connected to others); and the Precaution Adoption Process Model (PAPM) suggests that health behavior change is composed of several stages, leading from lack of awareness about a precaution to decision making, and in some cases, to adoption of the recommended precaution, initiation and maintenance (Weinstein 1988, Weinstein and Sandman 1992).

Among these theories, the Trans-Theoretical Model (TTM) has received the largest amount of empirical evidence to date. The TTM was constructed by integrating models of leading theories of psychotherapy and behavior change (Prochaska et al. 2002). A recent survey shows that the majority of tailored print communication health interventions use the Trans-Theoretical Model instead of other behavior change models (Noar et al. 2007). 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 will be most effective when 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. A meta-analysis of TTM-based smoking cessation interventions concluded that the majority of the studies yielded positive results in terms of the participants' change in Stage of Change, although many of these studies ignored the other measures in the TTM, which calls for future designs to adopt a more theory-based approach (Spencer et al. 2002). In one of the smoking cessation studies, 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 (Prochaska et al. 2001). 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 (Bock et al. 2001).

The Trans-Theoretical Model also classifies the hundreds of specific behavior change techniques that have been developed into ten 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 provide a description of the activities individuals need to engage in to move from one Stage of Change to the next. Ten Processes of Change have received the most empirical support to date. These Processes of Change are defined below (Prochaska and Velicer 1997), with examples drawn from a physical activity (PA) promotion intervention.

Consciousness Raising: Seeking information and raising awareness of target behavior. For physical activity, Consciousness Raising may include research on the pros and cons of exercising and paying attention to messages related to physical activity on the TV or the Internet.

Counter Conditioning: Replacing problem behavior with alternative behavior. For physical activity, Counter Conditioning can be using self-convincing arguments to exercise when one feels tired, stressed out, or simply not wanting to exercise.

Dramatic Relief: Experiencing and expressing feelings about problem behavior, such as through role-playing. For physical activity, Dramatic Relief may include thinking about oneself, people in one's social circles, or one's favorite TV character or game character, and imagining their life with and without regular physical activity.

Environmental Reevaluation: Assessment of the problem behavior's impact on the physical and social environment. For physical activity, Environmental Reevaluation can mean looking at the

society as a whole and examining the potential benefits of individual's physical activity behavior on society.

Helping Relationships: Seeking help from family, friends, or other caring individuals or organizations to change problem behavior. For physical activity, Helping Relationships may include seeking advice or help from a friend or family member, and finding time to work out with such friend or family member.

Reinforcement Management: Rewarding oneself or being rewarded by others for making progress in changing problem behavior. For physical activity, Reinforcement Management can mean giving oneself tangible rewards after meeting an exercise goal, or paying attention to positive changes in one's mood after a workout.

Self-Liberation: Realizing change is one's own choice and making commitment to change problem behavior. For physical activity, Self-Liberation may involve the commitment to develop the habit of exercising and realizing that any difficulties in the process can be overcome with enough effort and determination.

Self-Reevaluation: Emotional reevaluations of one-self in problem behavior and in alternative behavior. For physical activity, Self-Reevaluation can include thinking about the positive change to one's emotions and lifestyle when regular physical activity becomes a habit.

Social Liberation: Increasing awareness of social acceptance of alternative, better behavior. For physical activity, Self-Liberation may involve observing friends or neighbors performing physical activity, checking out gyms or community centers within one's neighborhood, and asking friends and family about their feelings of physical activity.

Stimulus Control: Controlling stimuli and cues that might trigger problem behavior. For physical activity, Stimulus Control can involve keeping workout clothes clean and at a convenient place, associating exercise with pleasant things such as music, and using a calendar to schedule regular physical activity.

The exact relationship of ideal processes of change to move forward from any given stage of change is different for each health behavior. For physical activity, a common mapping between the two constructs is illustrated in Figure 2.1.

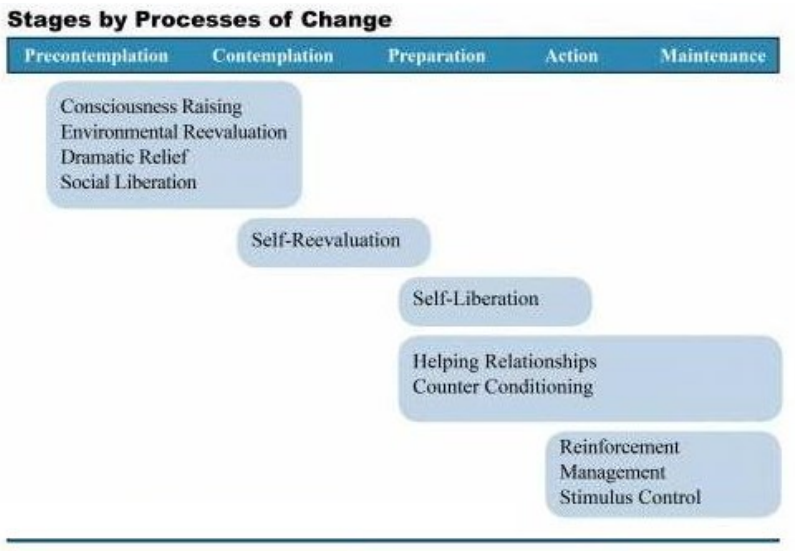

Figure 2.1. Alignment between Ideal Processes of Change and Stage of Change for Physical Activity

Chapter 3. Related Work

The framework described in this work is inspired by numerous research efforts on automating health behavior change interventions and interactive narrative systems. Some of the automated health interventions take the form of internet-based expert systems (Velicer et al. 1993), and a systematic review has shown that internet-based health interventions can promote significant health behavior change through more or less interactive features (Webb et al. 2010). Research in embodied conversational agents has also been applied to health behavior change interventions, and studies have shown that these virtual agents are capable of promoting behavior change through building relationships with users (King et al. 2011, Schulman et al. 2011). The research that is most closely related to this thesis is games for health, a review of which will be provided in this chapter. This thesis also builds heavily upon the use of narrative in health games, and two sections will be dedicated to narrative in health care and state of the art interactive narrative technologies applicable to game design.

3.1. 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 a 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. For example, there is now an annual “Games for Health” conference held in Boston. However, the games that have been developed suffer from a number of problems, including a lack of engaging mechanics, a lack of theoretical support from behavioral medicine, and poorly designed evaluations. Table 3.1 lists a total of 49 health games released between 1983 and 2014 that I have studied. Note that this is not an exhaustive list for it excludes games created only for competitions such as the Global Game Jam, and it excludes games without a name, as well as other experiences such as virtual-reality simulations that are considered to be games by some developers but do not really possess game elements.

Name	*Year*	*Target Behavior*	*Target Audience*	*Game Mechanics*	*Design Theory*	*Type of Intervention*	*Behavior Change Theory*	*Evaluation*	*Comparison to Other Games*	*Comparison to Other Interventions*
Asthma Command (Rubin et al. 1986)	1983	Asthma	7 to 12 yo	Platformer	N/A	One-time knowledge-based	N/A	Pre-post comparison trial	Compared to non-health game	N/A
Packy & Marlong (Brown et al. 1997)	1997	Diabetes	8 to 16 yo	Platformer	Early research on fun	6-month behavior-based	Self-Efficacy	Pre-post comparison trial	Compared to non-health game	N/A
Life Challenge (Thomas et al. 1997)	1997	Safe Sex	Out-of-school Youth	Fantasy role-playing	N/A	One-time behavior-based	Self-Efficacy and other Safe-Sex-Related Theories	Single-group	N/A	N/A
Dance Dance Revolution (Hoysniemi 2006)	1998	Physical Activity	Teens and adults	Dance-themed active game	N/A	Long-term behavior-based	N/A	N/A	Compared to non-health game	N/A
Watch, Discover, Think and Act (Bartholomew et al. 2000)	1999	Asthma	6 - 17 yo	Point-and-click Adventure Game	N/A	Multiple session by clinical visit	Social Cognitive Theory	Pre-post controlled trial	N/A	Compared to regular clinical visits
Asthma Control (Homer et al. 2000)	2000	Asthma	3 to 12 yo	N/A	N/A	Long-term behavior-based	N/A	Pre-post comparison trial	Compared to non-health game	Compared to book-based education
Carmen's Bright IDEAS (Marsella et al. 2003)	2000	Stress	Mothers	Choice-based role-playing	Rubber-band interaction model	8-week behavior-based	Cognitive Appraisal Models of Human Emotion	Pre-post comparison trial	N/A	N/A

Table 3.1. A list of games for health

Name	*Year*	*Target Behavior*	*Target Audience*	*Game Mechanics*	*Design Theory*	*Type of Intervention*	*Behavior Change Theory*	*Evaluation*	*Comparison to Other Games*	*Comparison to Other Interventions*
Bronkie the Bronchiasaurus (Lieberman 2001)	2001	Asthma	Children	Platformer	N/A	One-time behavior-based	N/A	Pre-post comparison trial	N/A	Compared to video intervention
IMPACT (Goran and Reynolds 2005)	2002	Physical Activity	Fourth graders	Interactive videos	N/A	6-month behavior-based	Social Cognitive Theory	Pre-post controlled trial	N/A	N/A
INSULOT (Aoki et al. 2005)	2003	Type I Diabetes	12 - 24 yo	Slot machine	N/A	One-time knowledge-based	N/A	Single-group	N/A	N/A
Squire's Quest (Baranowski et al. 2003)	2003	Fruit & Vegetable Intake	Children	Mini-games/puzzles	N/A	5-week homework-based	Social Cognitive Theory	Pre-post controlled trial	N/A	N/A
Sony EyeToy Series (Yavuzer et al. 2008)	2003	Physical activity	Teens and adults	Sports-themed active game	N/A	Long-term behavior-based	N/A	N/A	N/A	Compared to other types of intervention
Yourself! Fitness	2004	Physical activity	Teens and adults	Sports-themed active game	N/A	N/A	N/A	N/A	N/A	N/A
FearNot! (Aylett et al. 2005)	2005	Bullying	Children	Choice-based role-playing	Forum Theater	One-time usability test	N/A	Comparison study	N/A	N/A

Table 3.1. A list of games for health (Cont.)

Name	*Year*	*Target Behavior*	*Target Audience*	*Game Mechanics*	*Design Theory*	*Type of Intervention*	*Behavior Change Theory*	*Evaluation*	*Comparison to Other Games*	*Comparison to Other Interventions*
Nanoswarm (Baranowski et al. 2011)	2006	Type II Diabetes & Obesity	10 - 12 yo	Mini-games	N/A	9-session homework-based	Social Cognitive, Self-Determination and Persuasion theories	Pre-post comparison trial	Compared to game-based websites	Compared to game-based websites
Re-Mission (Beale et al. 2007)	2006	Cancer	13 - 29 yo	Third-person shooting game	Modeled after other game	3-month knowledge-based	N/A	Pre-post comparison trial	Compared to non-health game	N/A
Reach Out: Central (Burns et al. 2010)	2006	Well-being	18 to 25 yo men	Visual novel with role-playing	N/A	6-month behavior-based	Social Cognitive Theory, Cognitive Behavioral Theory	Single-group	N/A	N/A
Fish'n'Steps (Lin et al. 2006)	2006	Physical activity	Adults	Synchronization of player steps and fish growth	N/A	6-week behavior-based	N/A	Pre-post comparison trial	N/A	N/A
MetaKenkoh (Southard and Southard 2006)	2006	Nutrition	9 to 11 yo	Mini-games in the context of a story line	N/A	4-week behavior-based	N/A	Pre-post controlled trial	N/A	N/A
Wii Sports (Baranowski et al. 2012)	2006	Physical activity	Teens and adults	Sports-themed active game	N/A	Long-term behavior-based	N/A	N/A	Compared to non-health game	N/A
Escape from Diab (Baranowski et al. 2011)	2007	Type II Diabetes & Obesity	9 - 12 yo	Mini-games	N/A	9-session homework-based	Social Cognitive, Self-Determination and Persuasion theories	Pre-post comparison trial	Compared to game-based websites	Compared to game-based websites

Table 3.1. A list of games for health (Cont.)

Name	*Year*	*Target Behavior*	*Target Audience*	*Game Mechanics*	*Design Theory*	*Type of Intervention*	*Behavior Change Theory*	*Evaluation*	*Comparison to Other Games*	*Comparison to Other Interventions*
Sickle Cell Slime-O-Rama (Yoon and Godwin 2006)	2007	Sickle Cell Disease	7 to 14 yo	Question-answering mini-games	N/A	One-time knowledge-based	Self-Concept, Self-Efficacy	Single-group	N/A	N/A
Lumosity (Scanlon et al. 2006)	2007	Cognitive functions	Anyone	Click-based mini-game	N/A	Long-term behavior-based	Brain Training Principles	Pre-post controlled trial	N/A	N/A
NEAT-o-Games (Fujiki et al. 2008)	2008	Physical activity	Adults	Synchronized movement between player and avatar	Simple design principles	Multiple session usability test	N/A	Single-group	N/A	N/A
Fantastic Food Challenge (Silk et al. 2008)	2008	Nutrition	Low-income adults	Mini-games	N/A	One-time knowledge-based	N/A	Pre-post comparison trial	N/A	Compared to paper- and internet-based interventions
Akrasia	2008	Drug abuse	Teens and adults	Platformer	N/A	N/A	N/A	N/A	N/A	N/A
Personal Investigator (Coyle et al. 2009)	2009	Well-being	10 to 16 yo	Conversation-based role-playing in 3D environment	N/A	One-time behavior-based	Solution-Focused Therapy	Single-group	N/A	N/A
Re-Mission 2	2009	Cancer	Children	A series of games including platformers and drag-and-drops	N/A	N/A	N/A	N/A	N/A	N/A

Table 3.1. A list of games for health (Cont.)

Name	*Year*	*Target Behavior*	*Target Audience*	*Game Mechanics*	*Design Theory*	*Type of Intervention*	*Behavior Change Theory*	*Evaluation*	*Comparison to Other Games*	*Comparison to Other Interventions*
Blast-Off (Moore et al. 2009)	2009	Nutrition	6 to 11 yo	Drag-and-drop mini-game	N/A	3-month knowledge-based	Self-Care Deficit Nursing Theory	Single-group	N/A	N/A
RightWay Café (Peng 2009)	2009	Nutrition	Adults	SIMS-like simulation	Modeled after other game	3-week behavior-based	Social Cognitive Theory, Theory of Reasoned Action	Pre-post controlled trial	N/A	N/A
EA Sports Active Series	2009	Physical activity	Teens and adults	Sports-themed active game	N/A	N/A	N/A	N/A	N/A	N/A
SuperBetter (Roepke et al.)	2009	Illness/ injury recovery, depression	Adults	Goal-setting feedback platform	N/A	Long-term behavior-based	Cognitive Behavioral Therapy	Pre-post controlled trial	N/A	N/A
Neverball (Fitzgerald et al. 2010)	2010	Balance	Adults	Balance-based mini-game	N/A	4-week therapy	Self-Determination Theory	Pre-post comparison trial	N/A	Compared to wabble boards without the game
SpaPlay (El-Nasr et al. 2011)	2011	Physical Activity	Female adults	Spa simulation and mini-games	PENS (Player Experience of Need Satisfaction)	3-month behavior-based	Self-Determination Theory	Single-group	N/A	N/A
Family of Heroes (Albright et al. 2012)	2011	PTSD	Veterans	Conversation-based role-playing	N/A	One-time behavior-based	Social Cognitive Theory, Motivational Interviewing	Pre-post controlled trial	N/A	N/A

Table 3.1. A list of games for health (Cont.)

Name	*Year*	*Target Behavior*	*Target Audience*	*Game Mechanics*	*Design Theory*	*Type of Intervention*	*Behavior Change Theory*	*Evaluation*	*Comparison to Other Games*	*Comparison to Other Interventions*
PlayForward Elm City Stories (Fiellin et al. 2015)	2012	Adolescence risky behaviors	Teens	Mini-games weaved in a visual novel	N/A	6-week behavior-based	Social Learning Theory, Self-Efficacy, Message Framing, Delay Discounting	Pre-post comparison trial	Compared to non-health game	N/A
Zoo U	2012	Social Skills	Children	Point-and-click puzzles	N/A	One-time usability test	N/A	Single-group	N/A	N/A
SPARX (Merry et al. 2012)	2012	Depression	12 to 19 yo	Fantasy role-playing with mini-games	N/A	4 to 7-week behavior-based	N/A	Pre-post controlled trial	N/A	Compared to motivational interview intervention
Zombies, Run!	2012	Physical activity	Adults	Phone-based running game	N/A	N/A	N/A	N/A	N/A	N/A
The Time Mage (Yin et al. 2012)	2012	Patient empower-ment	Adults	Point-and-click visual novel	Flow theory	One-time behavior-based	Patient Activation, Self-Efficacy	Pre-post comparison trial	N/A	Compared to written-instruction-based intervention
Pocket Ritual	2013	Well-being	Adults	Card game	The Hero's Journey	N/A	N/A	N/A	N/A	N/A
GameOn	2013	Malaria	10 to 15 yo Kenyan	Mini-games/ puzzles	N/A	N/A	N/A	N/A	N/A	N/A

Table 3.1. A list of games for health (Cont.)

Name	*Year*	*Target Behavior*	*Target Audience*	*Game Mechanics*	*Design Theory*	*Type of Intervention*	*Behavior Change Theory*	*Evaluation*	*Comparison to Other Games*	*Comparison to Other Interventions*
Space Ranger Alien Quest	2013	Executive Function	Children	Mini-games to match food and drink to different aliens	N/A	N/A	N/A	N/A	N/A	N/A
Grounds-keeper (Heller et al. 2013)	2013	Attention Deficit Hyperactivity Disorder	6 to 17 yo	Whack-a-mole with tangible interface	N/A	One-time behavior-based	N/A	Single-group	N/A	N/A
Depression Quest	2013	Depression	Adults	Point-and-click visual novel	N/A	N/A	N/A	N/A	N/A	N/A
Zombie Yoga	2013	Physical activity	Adults	Kinect-based active game	N/A	N/A	N/A	N/A	N/A	N/A
Quit IT (Krebs et al. 2013)	2013	Smoking cessation	Adults	Role-playing	N/A	One-time usability test	Social Cognitive Theory	Single-group	N/A	N/A
LongStory	2014	Well-being	Teens	Adventure game / dating simulation	N/A	N/A	N/A	N/A	N/A	N/A
Ace's Adventure Game	2014	Pedestrian safety	Children	Mini-games	N/A	N/A	N/A	N/A	N/A	N/A

Table 3.1. A list of games for health (Cont.)

Early games for health often took on the form of “platformers,” a genre popularized by the Nintendo game Super Mario Brothers. These games, such as ***Packy & Marlon*** (Brown et al. 1997), allow the player to control a character who travels in a vertically-scrollable environment, where the player character is allowed to perform a limited number of actions, including walk, run, jump and interact with objects. Figure 3.1 is a screenshot of Packy & Marlon. As 3D technology became widely used, games for health also began to take on the action genre. For example, Re-Mission, a third-person shooter, has the player character float in a cancer patient’s blood vessels and shoot cancer cells (Kato et al. 2008). Some games take on a more narrative-based approach, where storytelling takes up the majority of the game, and mini-games or puzzles are used to increase the game’s interactivity and keep players engaged, as is done in ***Escape from Diab*** (Lu et al. 2012). Games for health are typically created by modeling other commercially successful games. For example, Re-Mission was created to simulate the structure of *Indiana Jones and the Emperor’s Tomb* using a typical third-person shooter’s mechanics. Although the game was evaluated in comparison to its model game on children with cancer (Kato et al. 2008), no evidence suggests that the game is more engaging than, or as engaging as, its model game through the eyes of an average player. Another example that’s been mentioned, Escape from Diab, is essentially a compilation of mini-games that have been published before, and the mechanics of these mini-games have nothing to do with the story line. The state of the art of health games seems to be replicating the mechanics of an existing game and adding health information to the game, which is neither theoretically supported or evidently engaging.

Figure 3.1. Screenshot of Packy & Marlon gameplay (Brown et al. 1997).

Evaluation

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 (Marsella et al. 2000). In the game, players take on the role of a counselor working with a troubled mother, and must try to help the mother through her stressful situations through the smart conversational choices. Figure 3.2 is a screenshot of Carmen's Bright IDEAS. 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 (Marsella et al. 2003). *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 (Thomas et al. 1997).

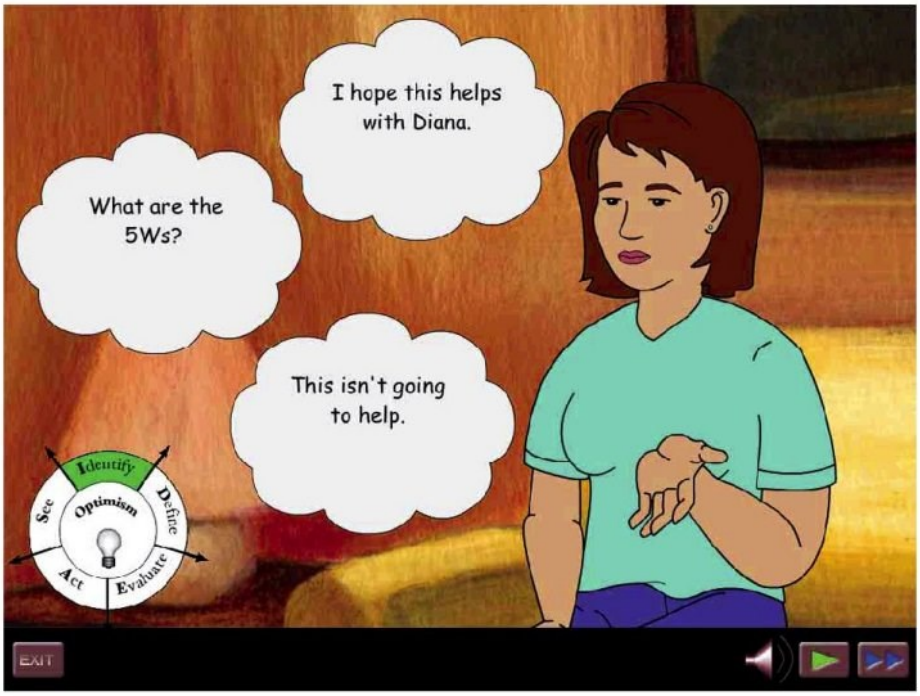

Figure 3.2. Screenshot of Carmen's Bright IDEAS gameplay (Marsella et al. 2000)

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 (Brown et al. 1997). *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*. In particular, after three months, participants' mean self-efficacy in the intervention group increased from 155.9 to 164.1 (n=164), while participants' mean self-efficacy in the control group increased from 156.6 to 158.8 (n=139). The intervention group also maintained significantly higher chemotherapy metabolite levels over time than the Indiana Jones group (Kato et al. 2008).

A few other games have been evaluated in comparison with other types of health interventions, but these evaluations each have their own flaws. In a randomized controlled trial of the ***Watch, Discover, Think and Act*** game, a health game aimed at improving asthma management among children, children using the game-based intervention in addition to their regular clinical sessions had significantly fewer hospitalizations than children without the game, but this effect is limited to children under 12 and does not show for older children (Bartholomew et al. 2000). The evidence also does not suggest the game outperforms regular clinical visits, because in the intervention condition, the game is given in addition to, not instead of, clinical visits. ***Asthma Control***, a computer game designed to teach children about asthma and its management, was evaluated through a controlled trial study 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 (Homer et al. 2000). Another asthma self-management education game, ***Bronkie the Bronchiasaurus*** (Figure 3.3), 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 (Lieberman 2001). Other studies revealed

less positive outcomes. Fantastic Food Challenge, a game-based intervention to promote healthy diets, was compared to print-based and Internet-based nutrition interventions, and the game underperformed both other media (Silk et al. 2008). SPARX (Figure 3.4), a fantasy role-playing / puzzle-solving game to combat depression, yielded lower rates of treatment compared to other monotherapies and smaller improvements on children's depression rating compared to drug-based interventions (Merry et al. 2012).

Figure 3.3. Screenshot of Bronkie the Bronchiasaurus gameplay (Lieberman 2001)

Figure 3.4. Screenshot of SPARX gameplay (Merry et al. 2012)

Overall, many health games have been evaluated in one way or another, and a lot of these games have been evaluated in controlled trials. In almost all of these evaluations, these health games significantly improved participants' knowledge on target behavior or promoted desired behavior among participants. I've collected information on 49 games for health through continued efforts of research between 2012 and 2015, summarized in Table 3.1. Only 7 of the 49 games (14.2%) have been compared to an alternative intervention, excepting Nanoswarm and Escape from Diab, both of which were compared to similar game-based interventions and not more conventional interventions. Some of these games underperformed alternative, more conventional interventions, and some others had questionable study designs.

There are also several recognized problems in the design of health games that must be addressed and can be tested in well-constructed evaluation studies. In games for health, game designers frequently sacrifice fun to make way for health messages, or the other way around. Many of these games are nonsensical, meaning their game mechanics are not related in any way to the health information they deliver. Most problematic games contain an overt display of serious content. These

problems quickly alienate players, who will disengage from the games, and consequently fail to receive the health intervention intended for them (Sinclair et al. 2007).

Exergames: Games to Promote Physical Activity

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. 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) (Graves et al. 2008). ***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 (Masek et al. 2009).

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 (Mhurchu et al. 2008). 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 (Owens et al. 2011). 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 (Graves et al. 2010). 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 (Baranowski et al. 2012). 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 (Maloney et al. 2012). 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 (Maddison et al. 2011). 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 (Warburton et al. 2007).

Recent studies have taken a closer look at the existing research and revealed several difficulties faced by the current games for health research. First of all, most existing games for health were not designed following sound health behavior change theories. Kharrazi et al. conducted a literature review of games for health and found only 18.8% of the publications surveyed applied an established behavioral change theory in the game design, while this number is less than 5% for

exercise-related games (Kharrazi et al. 2012). This makes it difficult to isolate the mechanisms that previous 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 are yet to be investigated on a large scale.

In exercise-related games, 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. Due to the lack of health behavior change theory in both the design of the games and the design of the evaluation experiments, the effectiveness of existing games for health on populations in different Stages of Change is difficult to evaluate. Second, many of the active games require players to exercise while playing the game, thus the game may be simply a distraction to the user, serving a similar function as a music player during exercise. A focus group conducted by Simons et al. reveals that adolescents who's played these active games find them less preferable than non-active games, mainly due to the lower quality of active games in terms of graphics, storyline, diversity of games, controls and technique (Simons et al. 2012). The potential of games as a motivation to exercise has not been systematically explored. Finally, the ultimate goal of games that promote exercise is to aim at the naturalistic setting rather than the laboratory. More than 70 percent of games for health studies are conducted in lab environments (Kharrazi et al. 2012). Studies conducted to test games for health in a naturalistic setting over a long term produce more meaningful results.

3.2. Using Narrative for Health Behavior Change

Many definitions of the word "narrative" exists, and for the sake of clarity, I will review a few widely used definitions. *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]" (Prince 2003). *The Cambridge Introduction to Narrative* offers a simpler definition: "the representation of an event or a series of events" (Abbott 2008). 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” (Polanyi et al. 1985). 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.

Narrative is crucial in learning: recipients of stories typically experience three steps in narrative learning: hearing a story, telling a story, and recognizing a story, i.e. realizing that the audience themselves are narratively constituted and narratively positioned in their environment (Clark and Rossiter 2008). In addition, Self-Efficacy theory points out that there are four major sources of information that may increase an individual’s self-efficacy: performance accomplishments, vicarious experience, verbal persuasion, and emotional arousal (Bandura 1977), where narrative belongs to vicarious experience, the second most effective information channel to improve self-efficacy next to a personal success experience. It is clear that narrative, when used correctly, may facilitate the learning of new information and improve self-efficacy, both of which are essential for promoting health behavior change. Therefore, it is no surprise that, in the field of health behavior change, more research has been done on narrative-based interventions in recent years.

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 (Houston et al. 2011). Slater and Rouner conducted a study testing the persuasiveness of different

types of messages regarding alcohol use. Their findings suggest that messages with statistical data are more persuasive than narrative-based messages 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 (Slater and Rouner 1996). 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 (Greene and LAURA 2003). 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 (Hinyard and Kreuter 2007). However, Slater et al. have noted that using a non-narrative summary after a narrative communication is considered more effective than using narrative alone (Slater et al. 2002). Lu et al. has concluded that narrative-based health games can, through immersing the player in the story world, positively affect the player's attitude, observational learning, emotional arousal, self-efficacy, subjective norms, and intrinsic motivation, which may lead to health behavior change outcomes (Lu et al. 2012).

There have been many models of successful storytelling (Brandt and Weiss 1998). One model that is widely accepted in popular culture explains a frequently used, recurring pattern in successful stories throughout history, including the Odyssey and Star Wars: the Hero's Journey (Campbell 2008). In the Hero's Journey, the hero of the story must go through twelve different stages before the story reaches its end. Figure 3.1 illustrates the process (Vogler 1998):

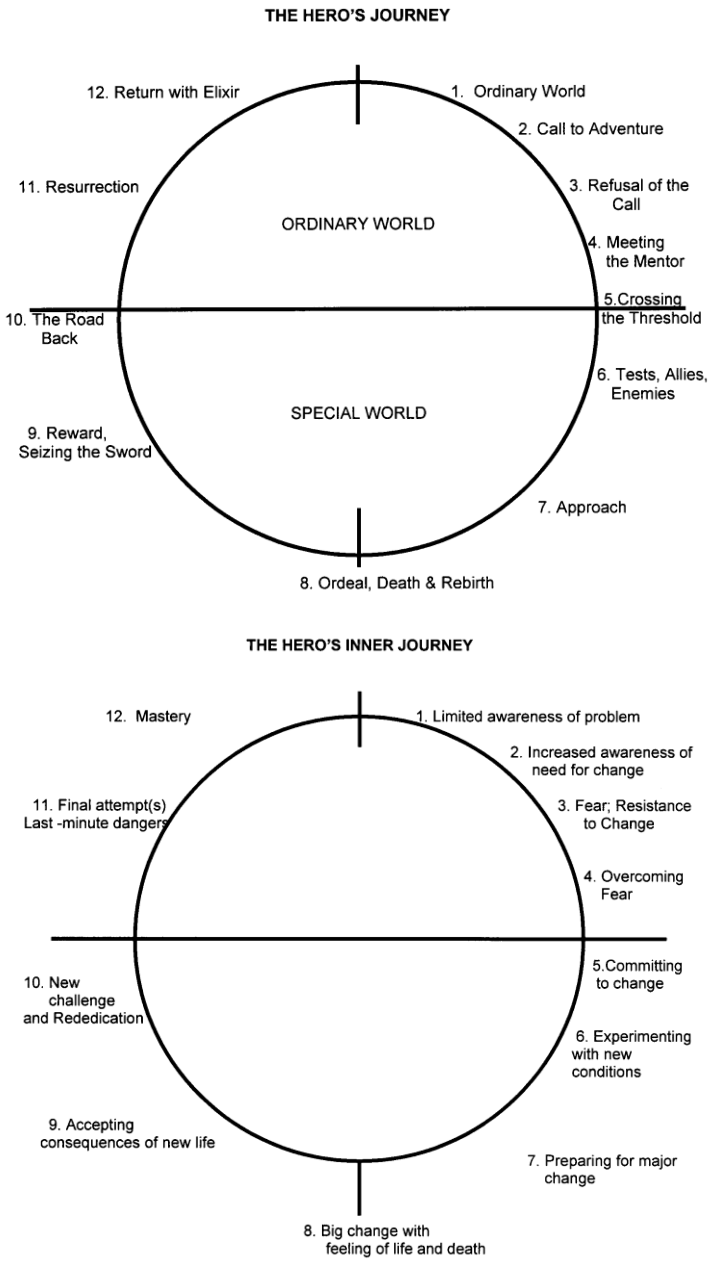

Figure 3.1. The Hero's Journey

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 (Vogler 1998), also shown in Figure 3.1. Vogler's statement suggests the Hero's Journey may be particularly valuable when integrated into a narrative aimed at promoting behavior change. Although other models exist and may be useful to game design, the Hero's Journey model can serve as a starting point for creating stories for new narrative games for health.

3.3. Intelligent Narrative Technologies

Interactive narrative is a game genre that has received much attention in recent years. The creation of *Façade* (Mateas 2002), among other interactive dramas, marks an era of significant progress in using intelligent narrative technologies to tell dynamic and tailored stories. A key invention in the field of intelligent narrative technologies is the 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 ***HAP*** architecture (Loyall 1997), aimed at creating believable drama characters, laid the foundations for the development of drama managers. The HAP architecture dictates that agents in an interactive drama must be reactive and responsive, modifying their behaviors as a goal becomes successful or the preconditions of a goal are no longer met. The first drama manager, MOE, was created to support an interactive drama: ***Tea for Three*** (Weyhrauch and Bates 1997). *Tea for Three* is a short interactive fiction story with sixteen critical 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 (Weyhrauch and Bates 1997). The drama manager in the interactive drama ***Mirage*** adopts a user model to generate future content and improve engagement. Mirage extends HAP's behavior representation to include a trigger, a priority, preconditions, postconditions, and sub-problems for each drama unit, i.e. beat. Mirage also infers the player's indecisiveness using the amount of time it takes the player to make choices in the game (El-Nasr 2007). 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* also generates story content in the form of beats, basic drama units

that contain a few turns of dialogue. The drama manager adds more features to the HAP agent architecture, including preconditions, effects (similar to Mirage's postconditions), a weight and a priority for each drama beat, 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 (Mateas 2002). ***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 (Young 2001). ***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 (Thue et al. 2007).

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 (El-Nasr 2007). 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 (Knickmeyer and Mateas 2005). 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 (Milam et al. 2008). There is no definitive answer to whether drama managers can create enjoyable interactive experiences, but existing research indicates that if the algorithm is carefully designed to maintain coherence and a proper pace, drama managers have the potential to maintain engaging player experiences.

Besides the drama managers mentioned above, there are other research projects that aim at generating coherent stories using computer algorithms. Lebowitz developed ***UNIVERSE***, which creates characters in a story world by defining their name, stereotypes, individual traits, individual goals, interpersonal relationships, marriages and history step by step to maintain consistency and coherence of the story (Lebowitz 1987). Bringsjord and Ferrucci created ***BRUTUS***, a narrative generator that forms story plots by generating actions for each character in the story world. The system first generates the characters' proactive behavior, which triggers reactive behavior from the characters on the receiving end (Bringsjord and Ferrucci 1999). Turner created ***MINSTREL***, a computer model of storytelling, based on knowledge of the specific domain of King Arthur (Turner 1994). MINSTREL employs a top-down approach to storytelling, first generating author-level goals based on a drama premise, then dividing the goals into sub-goals, which the system will solve by altering solutions already stored in its knowledge database (a.k.a. stories surrounding King Arthur). MINSTREL also adopts several modules to ensure the consistency of the generated story and apply dramatic techniques to make the stories engaging, including suspense, tragedy, foreshadowing and characterization. ***MEXICA***, developed by Pérez and Sharples, does not solely rely on intrinsic knowledge to generate story structures. Instead, MEXICA requires the user to input story knowledge and write several stories that the system will later analyze, based on which the system will generate new stories (PÉrez and Sharples 2001). Young et al. created Crossbow (Young et al. 1994), where the algorithm plans the course of a story by 1) deriving causal chains toward a goal and 2) decomposing higher level actions into lower level steps and 3) resolving conflicts that may undermine the goals during the narrative generation process. Similarly, his Mimesis (Christian and Young 2004, Young 1999, Young and Riedl 2003) conducts narrative planning by reacting to user actions that potentially break the consistency of the story. Riedl later proposed narrative mediation, a technique that attempts to predict the possible user actions that

may break a story's consistency before intervention to change the narrative (Riedl et al. 2003, Riedl and Young 2006, Young et al. 2004). The agents intervene the player's actions to ensure the narrative proceeds. Hills proposed a narrative generation framework where a story world is constructed using templates and user-input rules, where a story line is formed by creating a causal path in this story world (Hills 2010). Mott and Lester's narrative planner ***U-Director*** plans the narrative using generalized Bayesian networks that include utility and choice nodes as well as time-varying attributes, which takes into account the player's goals and beliefs when deciding what story to tell (Mott and Lester 2006). Fairclough's ***OPIATE*** operates by maintaining a world view containing the state of the story world and the state of the characters in it. The system uses a k-nearest neighbor algorithm to evaluate the suitability of potential scenarios to present (Fairclough 2007). The ***Marlinspike Interactive Drama System*** uses pre-authored scenes, dramatic units similar to beats in Façade, to construct unified stories, discovering necessary objects in the story and reincorporating them into the story context by picking scenes consistent with the process (Tomaszewski 2011, Tomaszewski and Adviser-Binsted 2011, Tomaszewski and Binsted 2009). Other researchers, such as Horswill, are concerned with the community's fixated attention on classical drama and have created narrative generators capable of telling stories of other genres such as farce (Horswill 2012). Li et al. used crowdsourcing to collect plot events, find the events and causal relationships among these events that are agreed upon, and presents these events as interactive stories (Li et al. 2012).

There has been some attempt to formalize the models that drama managers use. The drama manager employed in *Façade* is a declarative optimization-based drama manager (DODM), meaning the search for a dramatic beat is conducted using a Markov Decision Process (MDP) (Nelson et al. 2006, Nelson et al. 2006). A variant of the MDP model is the Targeted Trajectory Distribution MDP (TTD-MDP) model, where the repeated play of the story generation process will match a target distribution closely. Roberts' evaluation-based model is an example of TTD-MDP (Roberts et al. 2006). Cantino et al. extended TTD-MDP by providing good story prototypes and evaluating generated stories using a distance measured defined between the new story and the good prototypes (Cantino et al. 2007).

In addition to these narrative generation systems, many researchers focus on specific problems related to aspects of user experience and genres in the intelligent narrative domain. Mani created a system to evaluate reader's positive and negative empathy toward characters in a story through user annotations and aim to predict reader responses toward certain types of incidents by using a training set (Mani 2010). Tanenbaum et al. used cognitive hyperlinks to form connections between different objects involved in a story, creating the ***Reading Glove***, a tangible user interface used for ensuring the consistency of stories told in a random order (Tanenbaum et al. 2010). Niehaus and Young investigated the generation of stories that can prompt reader inference (Niehaus and Young 2010). Their system takes into account two types of user inference: causal inference, where the reader infers what happened in the story as the cause of evidence they observe, and intentional inference, where the reader infers a character's intention by understanding the state of the character. McCoy et al. describe Prom Week, a collection of social games played between the player and NPCs, where agents in the game act upon a knowledge database built on social facts, cultural knowledge, their social networks, social status rules that dictate certain relationships can be fulfilled, and personality descriptions to form goals, shape intents, and negotiate their roles (McCoy et al. 2012, McCoy et al. 2010). Sullivan et al. designed the ***GrailGM*** framework, which represents quests, NPCs, player actions and dialogues in a video game with a set of rules so that quests can be decomposed to sub-quests (Sullivan et al. 2010). By improving the clarity of quests in a game, GrailGM aims to improve player agency and hence player engagement. Giannatos et al. used a genetic searching algorithm, with three fitness functions of location flow, thought flow and motivation to add extra states to a story plan and, by changing the story structure with the new state, improves the story's quality (Giannatos et al. 2011). Lee et al. used a dynamic Bayesian network algorithm to learn to simulate the drama directing behaviors of a real human, using data collected through Wizard-of-Oz experiments in the ***Crystal Island*** game (Lee et al. 2011). Li and Riedl designed an algorithm that generates fictional gadgets in a generated story world by projecting properties from prototype objects to generated gadgets (Li and Riedl 2011). Shoulson et al. described the concept of selecting agents of different personalities and behaviors to fulfill certain roles in a story world in an attempt to accumulate character value and to facilitate the transition of

a character from the story's ambient background to the forefront interaction with the player (Shoulson et al. 2011). Giannatos et al. specifically investigated how to increase suspense in a story generated by a story planner (Giannatos et al. 2012).

Other research takes on a character- or agent- centered approach. Instead of generating narrative based on a premise or author goal, Cavazza's character feeling based model (Cavazza et al. 2002, Pizzi and Cavazza 2007), ***FearNot!*** (Aylett et al. 2005, Figueiredo et al. 2006), and Magerko and Laird's ***Interactive Drama Architecture*** (IDA) (Magerko 2005, Magerko and Laird 2003, Magerko et al. 2004, Magerko and Laird 2005) let each character in the story act upon their own goals, knowledge, and intentions. Riedl also attempted to compare the emergent story approach and the character-centered approach and create a hybrid system that takes advantage of both methods (Riedl 2010). Work in this area will not be elaborated upon in this dissertation.

The main problem that intelligent narrative technologies try to solve is creating interactive stories with a quality close to what is scripted by a professional storywriter. The current focus in this research area is to create small systems that fulfill a particular function. Despite the large amount of research available on intelligent narrative systems, little research has been conducted to explore the use of intelligent narratives for "games for health" or other serious games. One example of applying intelligent narrative to practical use is ***Maths4Kids***, created by Alexandre et al., a collection of mini-games aimed at improving 5-7 year old children's math skills (Alexandre et al. 2010). *Maths4Kids* uses narrative to introduce children to the game world. The game generates intermittent narrative dynamically to give children feedback on their performance in each mini-game. However, no evaluation study is conducted to test the game's efficacy in causing improvements in math skills.

Chapter 4. DraGuNa: Drama-Guided Narrative-Based Health Game Design

Although recent games for health research has placed a heavy emphasis on narrative, very little research has been conducted to incorporate sound narrative theories and techniques in the design of games for health. In addition, as described in Chapter 3, the majority of games for health are not based on any theoretical health behavior change model, which makes it less likely they will be effective at changing health behavior.

The framework I propose will fill these two gaps by adopting theories and techniques from drama to streamline the game design process and incorporating the Trans-Theoretical Model in the behavior change intervention that is part of a health game. The framework is named DraGuNa: Drama-Guided Narrative-Based Health Game Design. In this Chapter, I will discuss the two components of the DraGuNa framework. The first component aims to promote the player's adherence to the program's recommendations by providing incremental challenges based on the Trans-Theoretical Model and using motivating messages to encourage the players to make progress in their behavior change. The second component is focused on enhancing the player's engagement with the program by creating an appealing story with practical drama techniques and giving the player freedom to explore the story world through the use of intelligent narrative technologies.

4.1. The DraGuNa Framework

Following the Transtheoretical Model, this framework assumes that a given health behavior change intervention requires that a user perform a series of activities over time to incrementally increase their stage of change until they are in "maintenance", as detailed in Chapter 2. The specific activities are informed by the Transtheoretical Model, as instantiations of the processes of change appropriate for a user's current stage of change for the desired behavior. The framework further assumes that most of these activities (e.g., going for a walk) must be performed outside of gameplay sessions, and are thus referred to as "homework" exercises.

The DraGuNa framework divides the design process of a health game into two processes, engagement and adherence. In game design, there is significant disagreement on the definition of “engagement”, despite attempts made to create a unified definition (Brockmyer et al. 2009). However, for the longitudinal health games that the DraGuNa framework is designed for, the important function of game mechanics is to keep the player interested in the game for a prolonged period of time, so that the player is exposed to the most intervention content and homework exercise assignments. Therefore, in this work, I define engagement as the degree to which participants are willing to continue playing a game. Within behavioral medicine, “adherence” has been defined as the degree to which an individual is committed to a specific treatment and actively demonstrating desired behaviors (Meichenbaum and Turk 1987). When translated to the context of homework-based health games, adherence can be considered as the degree to which a player completes assigned homework activities.

The DraGuNa framework recommends that the game designer begin the game design process by clearly defining the boundary between engagement and adherence, considering them as two separate processes at the beginning of the design. Several techniques are recommended to be considered by the game designer in each process, to create engaging game mechanics and an integrated intervention. Once a game is created with basic game mechanics and a fully developed health intervention (the basic game), designers of the game are encouraged to answer further questions in the game’s context so as to combine the game mechanics and the intervention system into an integral experience. The overall DraGuNa framework can be illustrated by Figure 4.1, below.

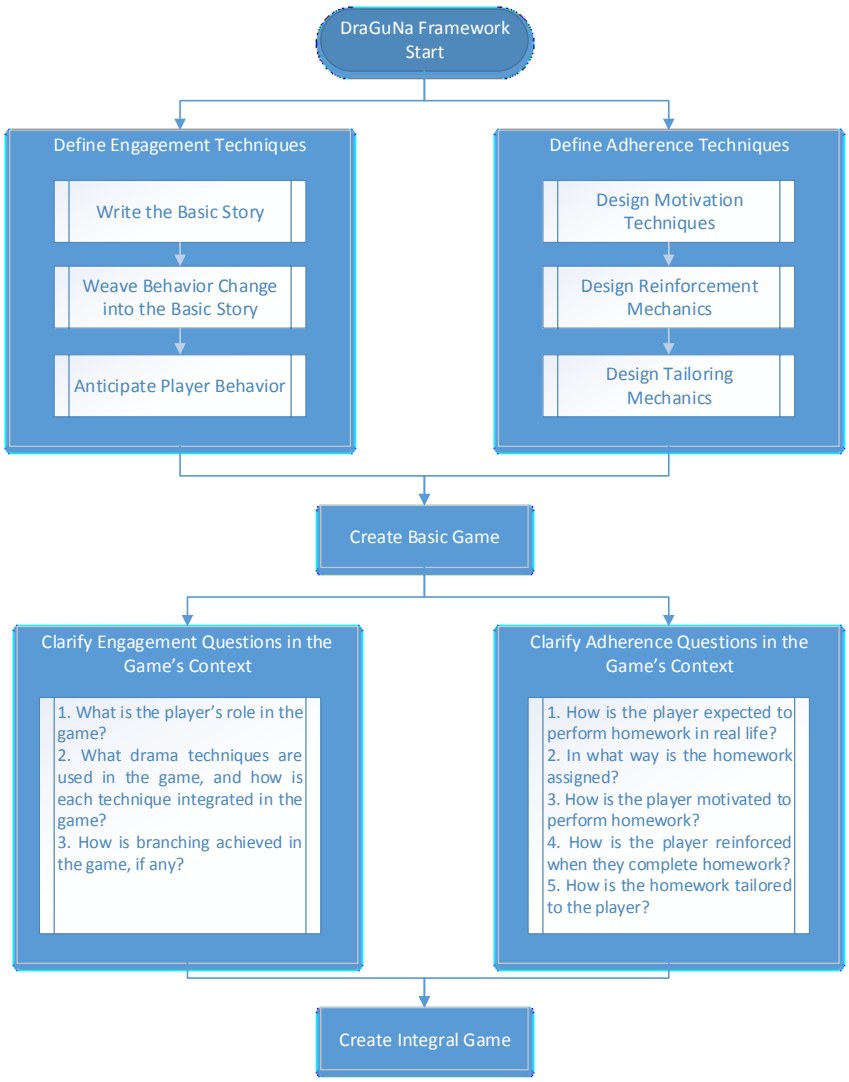

Figure 4.1. The DraGuNa Framework Diagram

At the end of the illustrated pipeline, an "integral game" is expected to have formed. However, this is not the final game. Numerous user tests must be performed to eliminate usability issues and to improve the game's playability and enjoyableness.

4.2. Promoting Adherence

The majority of games for health require players to perform all the activities associated with health behavior change while they are actually playing the game, but in recent years, health games with sound behavior change theoretical foundations have started to use "homework" as a means to achieve health outcomes. Here, I define "homework" to be activities the user takes outside of

gameplay that are intended to be instrumental in their health behavior change. For example, ***SpaPlay*** (also known as ***IgnitePlay***), an online social game where the player manages a spa and constructs utilities to attract visitors, uses homework by allowing players to perform health-related tasks (called sparks and quests) in real life to gain virtual currency to boost their performance in the casual games implemented on the platform (El-Nasr et al. 2011). It must be noted that the designers of SpaPlay defined adherence differently than I did in Section 4.1. In SpaPlay, adherence is defined as a composition of engagement, i.e. the number of log-ins, mean intervals between successive log-ins, and the standard deviation of days between log-ins (Durga et al. In Press). ***Super Better***, an online game to help individuals to recover from illnesses and injuries, and to help physically healthy individuals to cope with stress, uses homework by requiring players to assign themselves homework in several categories, and rewards the players with experience points when they complete the tasks (https://www.superbetter.com/).

As pointed out earlier, less than 20% of health games, and less than 5% of exercise-related games, have their designed based on a theoretical framework (Kharrazi et al. 2012). Sound behavior change theories and techniques can be used to improve a player's adherence to a health game, as is the one of the goals of this work. In this section, I explore a range of methods to implement a homework-based intervention system in games, and a list of techniques that can be applied to improve adherence.

4.2.1. Methods for assigning homework from a game

A game designer following the DraGuNa framework is encouraged to implement a homework system, serving as the essential part of the health intervention meant to be integrated into the game, because many activities encouraged by health behavior change theories are impractical while playing games, and because the assignment of homework mirrors the treatment given by good clinicians. The Trans-Theoretical Model posits an individual must go through a variety of changes to complete a cycle of health behavior change, and some of these changes must be achieved through social support and long-term habit forming, which cannot be done without some activities outside the game world.

One intuitive approach is to employ a quest system in a game, where the player can pick a homework assignment from a variety of tasks. This is in line with the design principles of the several existing health games. These games are designed so that the content of the quests are related to the premise of the game. In ***SpaPlay***, for example, quests include performing yoga or going jogging, whereas in the game the player manages a spa resort, where the player's customers will be doing the same. This is an intuitive approach for a homework-based game. Another approach to giving homework is by simply assigning the player one homework or a set of homework at the end of each session, based on the player's stage of change. This simple homework approach may lack relevance to the interactive content of the story, and may therefore appear incoherent to the user. To improve the coherence of this approach, the homework can be given in the context of the story, so that the user is led to believe they are performing tasks for or as the characters in the story, and that they are doing the homework to move the plot forward.

The DraGuNa framework recommends one of two ways to assign a homework to the player, which also integrates the quest system in the game's narrative: **narrator quest**, where the user receives homework through a narrator that exists outside the story, who requests the user perform a task to achieve some goal in the story, and **character quest**, where the user receives homework through one of the characters in the story, which directly requests the user's action by talking from the story's world to the user. To illustrate how each of these quest systems works, I will use examples from commercially successful games. Figure 4.2 is a screenshot from a popular online game, ***Game of Thrones: Ascent***. The game uses a narrator quest system which fits well with the game's strategy-based mechanics. Figure 4.3 shows a character quest system employed in ***Elder Scrolls V: Skyrim***, which suits the game due to its heavy role-playing nature. The character quest mode of homework may work better for a game where the player plays a character through first-person perspective and role-play is heavily emphasized, whereas the narrator quest mode of homework may work better when the player character is perceived through a third-person angle.

Figure 4.2. Narrator quest system in Game of Thrones: Ascension

Figure 4.3. Character quest system in Skyrim

For behavior change to occur, it is necessary to make the player understand that the homework assignments are not meant for the player character, but for the player themselves. This requires the game's story to communicate directly with the player, past the player character. One particular

technique developed for this purpose and adapted in many genres of literature, including drama, comic books and video games, is *breaking the fourth wall*.

The “fourth wall” is a term used to describe the invisible barrier between a play and its audience, in addition to the left, right and back walls in theatrical building sets. Breaking the fourth wall is a technique used in ancient Greek theater and Shakespeare alike, where characters in the play directly address the audience and acknowledge their own fictional nature. The technique has been used in many different genres. For example, in the 2013 TV show *House of Cards*, the main character Francis Underwood often turns his head to the camera and speaks out his concealed plots and true opinions of other characters to the audience; in the movie *Kick Ass*, the protagonist discusses superhero tropes with the audience as they come up, and warns the audience that he might not survive just because he is narrating the story; a famous comic book example exists in the Marvel series *Deadpool*, in which one of the protagonist Deadpool’s superpowers is to talk to the reader directly, and he constantly refers to the “yellow boxes” where his thoughts and speech appear; and in the video game series *Metal Gear Solid*, characters repeatedly speak to the player directly to provide instructions to playing the game, and in certain places in the series, the player will be led by the game’s instructions to perform real-life tasks, such as switching their game controller from one port to the other, in order to win a battle.

Breaking the fourth wall can be used to address the player’s health behavior change in a health game without breaking the suspension of disbelief. A possible approach is one much similar to the style used in *Metal Gear Solid*, where characters directly refer to the fact that the player is playing a game, and that the player has access to the environment in the real world, thus capable of performing tasks in it. However, a fine line must be drawn between breaking the fourth wall and throwing health interventions directly at the player.

4.2.2. Techniques to improve adherence

Using the DraGuNa framework, the game designer is required to use techniques to improve the player’s adherence to the intervention part of the game. Three high level approaches are recommended: motivation, reinforcement and tailoring.

Motivation

According to the Trans-Theoretical Model, individuals in the Pre-Contemplation and Contemplation stages do not have enough motivation to engage in health behavior change. Physical activity homework for these individuals needs to focus on helping them realize exercise has practical benefits, is not burdensome, and can be fun, and that not exercising does long-term harm to their life. However, in addition to this, the homework itself needs to be presented in a way to motivate the user. Roberts, et al. have identified six principles of influence from years of research in social psychology and behavioral finance: 1) Reciprocation: give and take; when someone does something for us we feel obligated to return in kind. 2) Consistency: we have a near-obsessive desire to appear consistent with what we have already done or said. 3) Social proof: we look to others, especially those similar to us, to determine the appropriate action to take. 4) Liking: the more we like someone, the more willing we are to acquiesce to her requests. 5) Authority: we have a deep sense of duty to authority. 6) Scarcity: something that, on its own merit, holds little appeal to us will become decidedly more enticing if it will soon become unavailable to us. Roberts et al. implemented the principle of scarcity in an interactive game developed by piecing together Youtube videos. In a controlled trial, participants influenced by scarcity reached a specific story state intended by the researchers significantly more than those in the control condition (Roberts et al. 2009).

Reinforcement

Operant conditioning is the behavioral process where the addition or removal of a stimulus is used to maintain the frequency of a behavior. Operant conditioning can be divided into reinforcement and punishment, where reinforcement is used to encourage a desired behavior, and punishment is used to discourage an undesired behavior (Skinner et al. 1972).

Users may also be encouraged to perform their assigned homework through proper reinforcement. Negative reinforcement and punishment will not be employed in the study. Constraints and punishment can cause participants to withdraw from the study instead of achieving the desired

behavior change outcomes. Positive reinforcement can be integrated into the system to reward users when they complete homework or when they make a proper choice for the story, the latter being part of agency. Intermittent reinforcement has rarely been tested in a health behavior change setting, but may be more effective at behavior change than positive reinforcement alone (Kendall 1974).

Positive reinforcements have been widely used in story-based video games already. One of the earliest and still most well-known role-playing games, ***Dungeons & Dragons*** introduced the concept of character experience and character level. By killing enemy monsters and, sometimes at the game master's discretion, finding creative solutions to advance the story, the player's character gains experience, which will cause the character to level up at intervals and become more powerful. This increases the player character's survivability and capability in the story world, at least from the player's perspective. The experience model has been prevalent to this day, but many games have replaced it with new approaches. In Assassin's Creed, for example, the player character Altair gains an improvement in his health and additional assassination tools each time the player finishes a section of the story.

Reinforcements in the intervention can manifest in a number of ways. The program can present the user with a physical reward of monetary value, such as a gift card (Vardoulakis 2013), or simply cash (Bickmore et al. 2010), and instead of rewarding the user for using the system, as was done in the cited work, these rewards can be given for completion of homework assignments. Alternatively, the program can offer the user a virtual asset related to the game they are playing, such as extra satellite stories surrounding the main theme, hidden background stories of the protagonist, or wall papers featuring the game characters. Another way that's appropriate if the user role-plays a character in the story is letting the user's character receive an in-story reward. These rewards must have a purpose in the story that may materially impact the story progression. The in-story reward is also a design opportunity to improve the player's engagement through increased agency, as the player would feel their actions have an impact in the game world, to be further explained in Section 4.2.3. There are also multiple ways to facilitate intermittent

reinforcement. Physical rewards and virtual assets can be offered to the user randomly or following a schedule the pattern of which is not perceivable by the user. Physical rewards can also be given periodically based on a random drawing, as in the study of Vardoulakis (Vardoulakis 2013). Alternatively, the program can provide the user with tokens of different design. Each of these tokens can unlock a particular type of reward. A complete set of these tokens may redeem a final reward. However, extra caution must be taken when giving out tokens, badges and the like. Although these rewards are common in gamification, successfully implementing them requires meaning to be attached to these rewards. Games on major game platforms, such as XBOX, Playstation and Steam use badges to motivate players to exhaust possibilities in the games they play, but that assumes that the player is already engaged with playing the game.

Tailoring

"Tailoring" is the method of creating communications in which information about a given individual is used to determine what specific content he or she will receive, the contexts or frames surrounding the content, by whom it will be presented and even through which channels it will be delivered, a process aimed at enhancing the relevance of the information presented and thus producing greater desired changes in response to the communications (Hawkins et al. 2008). Tailored messages have been shown to outperform non-tailored messages in promoting health behavior change (Noar et al. 2007), and tailoring health messages to the user has been shown to improve adherence to the program (Kreuter et al. 1999, Strecher 2007). Tailoring is becoming a common practice in health behavior change interventions, and therefore is recommended to be incorporated into health games.

Chapter 2 discussed homework assignments to promote physical activity based on Stage of Change and Processes of Change. Constructs such as Stage of Change provide an important opportunity for tailoring: individuals should receive interventions tailored to their specific Stage of Change. Besides these Trans-Theoretical Model-based factors, an intervention can be tailored to many other aspects of an individual: age, ethnicity, culture, profession, personal capabilities, family influence, etc. There is a large and blooming area of research on tailoring, and this thesis will only focus on TTM-based tailoring, but a game designer using the DraGuNa framework is encouraged

to study the target audience, understand the factors that are important to each individual in the audience crowd, and apply appropriate tailoring to both the game's story and the homework.

4.2.3. Additional questions for the designer

As a game designer decides on the method of implementing a health intervention in the game and employs the above techniques to improve player adherence, and after the designer applies the engagement techniques discussed in the following section, a prototype game will slowly come into shape. Once this basic game is finished, a few more questions must be reviewed to help the designer understand the combined impact of the engagement and adherence techniques and make informed improvements to the intervention:

1. How is the player expected to perform homework in real life?
2. In what way is the homework assigned?
3. How is the player motivated to perform homework?
4. How is the player reinforced when they complete homework?
5. How is the homework tailored to the player?

Each of these questions must be answered within a specific game's context, with both engagement and adherence techniques initially employed. The answers to these questions can help the game designer anticipate player behavior, thus making adjustments to the adherence strategies to enhance the player experience. I will discuss the process of answering these questions, and in Chapter 5, I will offer further explanations in a sample game context.

Question 1: How is the player expected to perform homework in real life?

A Trans-Theoretical Model-based intervention typically takes months if not years to complete, and a small number of assessments and feedback are usually given to each individual going through the intervention. This differs from the horizon that a typical computer or video game spans across: Unlike a TTM-based expert system, a health game usually only sustains the player's engagement for a few days or weeks, and unlike an expert system whose primary purpose is to provide feedback, a health game is a platform to take an active role in promoting health behavior change. Therefore,

the DraGuNa framework recommends a health game to trigger TTM-based feedback as the player progresses to certain points in the game, but a means to assess the player's health behavior change is needed, and feedback alone may not be enough to incur a significant amount of behavior change. The use of homework assignments pertaining to the various Processes of Change and Stages of Change solves both problems: it is an active way of helping the player progress toward the next stage in their exercise behavior, and the player's completion of the homework serves as an indicator of how they progress toward their next stage of change. Other types of report mechanism, such as data from a pedometer or sensory input are also encouraged for assessing the player's progress from time to time.

Another important question that arises here is whether the player should perform the homework assignments during his or her game play, such as in Wii Sports, or perform the tasks between game sessions? When using the DraGuNa framework to design a narrative-heavy health game, introducing behavior-based work within the story, if not handled well, may break the magic circle, hence reducing the player's engagement. Therefore, the game designer is strongly encourage to employ homework assignments between game sessions instead of within.

Question 2: In what way is the homework assigned?

For homework to be assigned as part of a game, I recommend the game designer to create homework assignments that make sense in the game setting, otherwise it can potentially break the believability of the game. It is also the presumption of most health games that the health message must make sense in the game setting, be it cancer cells in Re-Mission, or Diab, the town filled with junk food in Escape from Diab. Therefore, a basic story of why the player needs to perform these homework assignments must be weaved into the main story.

For a behavior change to make sense in a game's story, the behavior change can be directly or indirectly associated with the story. In a story with which a behavior change is directly associated, the protagonist or the game's main non-player characters may need to change the target behavior to achieve a grand goal, and the player must make his or her character work hard to achieve

behavior change, or try to help other characters to achieve the behavior change. This is the approach used in Escape from Diab. However, this approach can come out as too obtrusive and may repel players who find the intervention being thrown to their face. In a story with which a behavior change is indirectly associated, the player may start the game engaged in a task completely irrelevant to the behavior change, but as the game progresses, the player may be required to engage in the behavior change as a side quest, which helps the player achieve a better outcome in the story.

Question 3: How is the player motivated to perform homework?

The player's continued completion of their homework is the quintessential factor of adherence as defined in this work. An important purpose of the game and the DraGuNa framework presented in this thesis is to motivate the player to complete their homework over a prolonged period of time. The motivation techniques described in this chapter must be properly combined with reinforcement and tailoring methods within the game's context to achieve player adherence.

Typically, when a player receives a homework assignment, the player has two options: accept it or reject it, unless the game forces the player to accept. When a player returns to the game, there are typically two outcomes of the player's previous homework assignment: the player completed it or failed it. Therefore, motivation techniques can be used in two places: to increase the chance that the player will accept a homework assignment, and to increase the chance that the player will complete a homework assignment. The designer must decide which of the two places to apply the motivation techniques discussed earlier in this chapter, if not both, and how to integrate the message into the story.

Question 4: How is the player reinforced when he or she completes homework?

In a health game, when a player completes a mission, the player expects to be rewarded in some way that encourages him or her to continue completing missions in the future. I explored several different ways of rewarding the player in this chapter, including rewards with real monetary value

and extra features related to the game. The game designer must decide which reinforcement methods are appropriate for a particular game.

It is also important to ensure that the rewards the player receives build up to a higher goal, or the player may feel the rewards are meaningless, just like poorly-designed badges in a gamification. Narrative-heavy commercial games build a complicated reward system by replicating a reward system recursively, allowing the player to accumulate smaller rewards to unlock rarer ones. For example, in Personal 4 Golden, a role-playing game with visual novel elements, the player is encouraged to spend time with non-player characters in his spare time. By spending time with NPCs, the player character forms “social links” with them, which unlocks certain abilities in the player’s team members, making them stronger in combat, or provides benefits such as discounts toward a particular service in the game. When the player spends enough time with one of the NPCs (usually ten times given the player makes every choice in the NPC’s favor), the player and the NPC will form an unbreakable bond, and may enter into a relationship if the NPC is a female character (the player character is fixed to be male). This unbreakable bond will allow the NPC’s supernatural powers to evolve, granting bonuses as a reward. As another example, in Danganronpa 2, a highly successful suspense visual novel, the player is encouraged to spend time with the 15 non-player characters in the game. Every time the player character spends time with an NPC, the two characters will grow closer, and the player will gain a piece of “hope fragment”. With enough hope fragments, the player can purchase skills from a special NPC that can be used in the next “class trial” (which is the action-heavy portion of the game). However, spending time with NPCs does not just stop here. If the player character talks to any particular NPC five times, the player will earn enough trust from the character to learn his or her past secrets, upon which time the player will learn a unique skill that can only be unlocked by completing the NPC’s story arc. These unique skills are often more powerful than the skills purchased using hope fragments, thus giving the player incentive to complete as many characters’ story arcs as possible.

The approach taken by the aforementioned commercial games is a feedback loop, as illustrated in Figure 4.4. A game designer can easily apply this approach in a health game, as long as all the rewards are consistent with each other and make sense in the game's context.

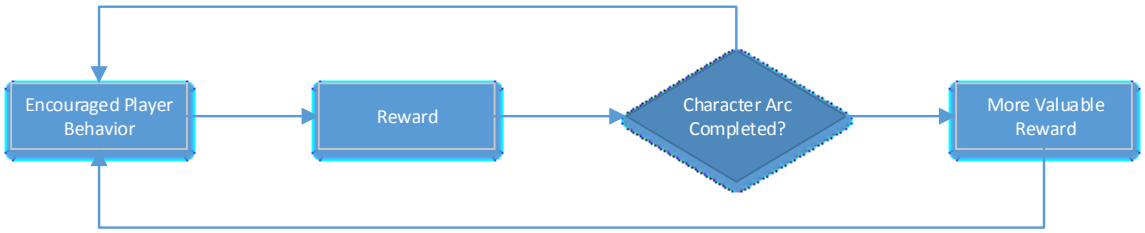

Figure 4.4. Feedback loop of narrative-heavy commercial games

Question 5: How is the homework tailored to the player?

Homework assignments can be tailored to the player in a variety of ways and on a variety of levels. Homework assignments can be tailored by Stage of Change, where players in different Stages of Change receive different homework assignments; they can also be tailored to Processes of Change, where players lacking in particular Processes of Change receive homework assignments targeting these Processes of Change specifically; homework can also be tailored based on the player's preferences, such as whether they prefer to perform an activity alone or with other people. For example, a player who prefers to exercise alone may benefit less from a homework assignment that encourages the player to work out with friends.

In an ideal case, tailoring is done continuously during game play. As the player progresses in the game, days and weeks will pass. The player may be influenced by the game experience and start changing his or her behavior. For example, a player may begin playing a health game in the Contemplation stage, and after finishing a few missions, the player may feel ready to start making a change. In this case, it is reasonable to reassess the player's Stage of Change and, upon detecting a change in the player's behavior, adjust the homework assignment scheme.

4.3. Promoting Engagement

Traditional storytelling has produced many techniques to improve the audience's engagement, and many of these techniques have been prevalent in commercial games. When transforming a story to an interactive game, these techniques can still be employed to generate engaging experiences. As part of the DraGuNa framework, a few of these engagement techniques commonly employed in drama are recommended to be carefully applied in a health game (Egri 2007, Turner 1994). Also recommended are a series of principles used in video game design to improve player engagement. These techniques will be explained in the next few sub-sections.

4.3.1. Engagement techniques in drama

Suspense: Suspense is common among all forms of storytelling. A simple way to improve engagement of a game is through constant suspense. In ***Danganronpa***, a visual novel best known for its breathtaking story, suspense is constantly applied across the entire game: the player is first given the puzzle of how he and another 15 high school students, all of whom have lost their memories, ended up in a twisted killing game, and as the game progresses, the antagonist will intentionally give the player a hint in every chapter, which would cause the player to delve deeper into the puzzle, yet uncovering only more questions than answers. In an interactive game expanding across multiple reading sessions, it is necessary that suspense is created at the end of each session to keep the users coming back.

Characterization: Characterization is the traits displayed by characters in a story. Freeman has introduced a technique of creating memorable characters in Emotioneering (Freeman 2004). Following Freeman, a character can be created by developing a trait diamond, where a character's personality can be described by three to five traits. To make a character memorable and relatable, these traits are recommended to be non-stereotypical. The relationships between these traits can also be seemingly conflicting, but if deeper motives or the personal history of the character are revealed, the traits will likely make sense to the player. When expanding on an existing story, it is the author's job to distinguish each significant character's trait diamond. These traits can then be

used to model how the characters would each treat the player and what type of interactions the player can have with these characters outside the framework of the existing story.

Tragedy: In drama, tragedy occurs when a character that the audience relates to and sympathizes with encounters ill fate. This usually results in said character losing something dear to her, being in pain, or dying. Tragedy is not necessary in all types of drama. It is dependent on the genre and the message being delivered. In an interactive game, tragedy can be employed to motivate the player to achieve certain goals because they want to help or avenge the characters to whom tragedy has occurred. However, given the story used in this work, tragedy will not be applied to the story in a dynamic fashion.

Transition: Transition is the process that describes the growth of a character, or the growth of the relationship between multiple characters. Transition is the essential force that drives a story to progress, as it is the critical process of character growth as well. For example, the hero's journey describes a type of transition where a character becomes mature and powerful through the course of a story (Campbell 2008). In the video game ***Assassin's Creed***, Desmond Miles does not understand the assassin's discipline even though he was born an assassin. As he gets to learn his ancestors' struggles against the Templars, his character transitions and he begins to work with other assassins and to atone with his father. Good transitions invite the audience to invest emotionally in a story and are part of the engagement of a game.

Foreshadowing: Foreshadowing is the technique where the author uses a threat to prepare the reader for a major conflict. In the visual novel ***Ace Attorney***, the story introduces the protagonist Phoenix Wright and his old friend turned foe prosecutor Miles Edgeworth. The story tells the complicated relationship between the two, making it clear that Phoenix and Miles are men with different ideals, but they are the same in defending what they hold true. This relationship serves to signal the later part of the story where Edgeworth was prosecuted and he asked Phoenix Wright to be his lawyer. In a long serial story where the player's role transitions over time, foreshadowing can be used to prepare the player for this change. The player's relationship with each character in the

story may start from one pole and transition to the other end towards the end of the game, and the non-player character's attitude change toward the player can foreshadow this transition.

Movement: Movement describes the process of a well-written conflict: the most engaging type of conflict is that which is moving back and forth, where one side attacks and the other counterattacks. In the popular detective visual novel ***Danganronpa 2***, the player character and the antagonist are competing to sway fate to their favor: the antagonist, Junko, plots to kill several of her disciples in a computer simulation, upon the death of whom, Junko's personality will be uploaded to the dead disciple's body and rise to bring destruction to the world, whereas the player character, one of Junko's disciples, not knowing Junko's plot, struggles to survive in the computer simulation, where he and the other 15 disciples are forced to kill each other. In the game, the disciples are trapped on an island, where certain sections of the island are blocked by mono-beasts, powerful machines that prevent the player character from venturing further. However, after each class trial, where two or three fellow disciples would die, their powerful ally, Monomi, would defeat a beast and unlock a portion of the island, where the player learns new secrets of Junko. Each chapter of the game is composed of loss of several characters, furthering of Junko's plot, and the unlocking of the island, pushing the player character closer to defeating Junko, thus forming movement. In the example, not only does movement itself increase engagement, it also provides suspense and creates cliff-hangers.

4.3.2. Engagement techniques in games

Narrative-heavy video games have developed an additional set of engagement techniques to aid the delivery of drama. In the Mechanics, Dynamics and Aesthetics (MDA) framework, a formal approach to game design and research, Hunicke et al. proposed eight significant elements that engage players on the aesthetics level: sensation, fantasy, narrative, challenge, fellowship, discovery, expression and submission (Hunicke et al. 2004). In a typical role-playing game such as ***Final Fantasy***, fantasy, narrative, challenge, discovery, expression and submission are the key elements that keep players engaged. Besides narrative, which has been discussed extensively in

this thesis, each of the five other elements deserves to be examined for its applicability in a game within the constraints of this work.

Fantasy: Many role-playing games tell stories in a sci-fi (e.g. ***Mass Effect***) or fantasy (e.g. ***Dragon Age: Origins***) setting. The fantasy element is often an obvious element that determines whether a player will attempt to play the game. Fantasy exists in some visual novels too, such as the game Fate / Stay Night, which tells the story of sorcery wielders in modern Japan, and Myst, in which the player is transported to a surreal island through the magic of a book. However, fantasy is not a necessary element in visual novels. Many successful visual novels feature stories in a real-world setting, such as Ace Attorney and Katawa Shoujo.

Challenge: Challenge overlaps heavily with the concept of hard fun in Lazzaro's fun factors model (Lazzaro 2004). A typical role-playing game challenges the player with stronger foes that the player character has to fight against as they progress and gain powers through the story. This approach alone is perceived as insufficient in the modern era. Advancements in video games have introduced many different ways to challenge the player. For example, in each ***Final Fantasy*** game, there are boss fights that the player has to win by employing unusual strategies. These boss fights are completely optional but highly rewarding. In many western role-playing/action games nowadays, game designers interweave action challenges and other types of challenges. For example, in God of War, a combat sequence usually leads to a puzzle, and at the end of a puzzle, the player is usually welcomed with a more challenging combat sequence. Similarly, in ***Assassin's Creed***, a combat sequence is usually followed by a stealth mission, such as eavesdropping, assassination or thievery. Players are also challenged to adapt to new game mechanisms in most modern games. In the games Tomb Raider and The Last of Us, as examples, the player characters will acquire new weapons and unlock new abilities of these weapons. Using these weapons is usually necessary for finishing the game, but each of these items requires practicing to be used efficiently. Except for the ***Danganronpa*** series, where the player is rewarded skills that may give the player an advantage in class trials each time the player completes a character's side story, it is not common for a visual novel to employ challenges in the methods above, but in a similar way, visual

novels usually reward players with key items or information that will help them resolve puzzles in the story. This technique will be used in this work to improve player engagement. Some visual novels also limit how long the player can take to choose an option, such as ***The Walking Dead*** and ***Sakura Wars***. This creates tension and challenges the player to pay attention to the game and respond in a timely manner.

Discovery: Discovery corresponds to the concept of easy fun in Lazzaro's fun factors model (Lazzaro 2004). This includes the discovery of a location or a culture: when the player discovers Shamballa following Nathan Drake's treasure map in the game ***Uncharted 2***, the experience of an astounding view and an unexpected civilization adds to the game's engagement. Discovery can also be the revelation of new ideas. Many visual novels rely on an idea or a philosophy to keep the player engaged. Take a recognized visual novel, ***Never 7***, as an example: the player is required to play the game multiple times to complete it. In the first game play, the player is lead to believe the player's summer camp team is trapped in a time loop, where a tragic event is bound to happen over and over again, repeating a week-long cycle. In the next few game plays, the player tries different ways to get out of the time loop. After all the possible attempts, the player discovers the entire summer camp is an experiment conducted to investigate a phenomenon where two believers' delusion can spread among several individuals and eventually become reality. The player will realize that the experiment started with two NPCs believing the player character has déjà vu, but soon evolved into the group believing the player character has the ability to time travel. The entire game is built upon a puzzle of several things to be discovered, which makes the player eager to go from one plot point to another. Discovery can also be about new abilities or items at the player's disposal, especially if these abilities and items introduce new strategies to win the game. One example is ***Final Fantasy VII***, in which the player characters pick up magic stones with a variety of powers called materia when they travel the world. As the player progresses through the story, they will discover materia with more powerful spells. In addition, these materia can be used in connected slots in the characters' equipment to produce effects many times stronger than they are used alone. These combinations will also have strong effects against certain types of enemies and weak ones against others. This requires the player to try out different combinations of materia when they

discover a new one. Discovery of items, abilities and new sites can be implemented in a visual novel as described in this dissertation, especially as a mechanism to reward the player's involvement with the story and their performance in homework.

Expression: Expression is self-discovery, where the player expresses their feelings or empathizes with the game characters' emotional expressions. One example of this type of engagement can be found in the game ***The Last of Us***. The story takes the player through a post-apocalypse world filled with zombie-like creatures. The player experiences the story through Joel, a middle-aged man who's lost his daughter to the apocalypse. The player character is forced to take on a job to escort a little girl Ellie, who happens to be about the age of Joel's daughter when she died, to a revolutionists' camp. Joel forms an emotional bond with Ellie during the journey, and at the end of the trip, Joel risks his life and the chance to find a cure to the zombie virus for Ellie's survival. Joel ends up making hard decisions, killing revolutionists who want to retrieve an anti-virus from Ellie's body and lying to Ellie about his many murders. The game reaches an emotional climax at the end of the story. This level of engagement is difficult to achieve even with scripts written by professional screenwriters through years of effort. As a result, this thesis will not be concerned about expression, and rely on the story chosen to deliver the emotional impact that the author is capable of.

Submission: Submission is pass-time, where a player is enchanted to engage in a behavior for a prolonged period of time. Submission means that a game provides a player with something to do over and over again when the player has no other important engagements. Even though role-playing games and visual novels are centered on the quality, rather than length, of a pre-scripted story, number of hours of game play is still a significant measure of a commercial game's worth. Therefore, story-heavy games typically employ several techniques to expand the types of things a player can do. For example, ***Final Fantasy*** series always offers a list of hidden quests that the player can engage in. These quests will reward the player with very powerful or very interesting items or abilities, which will help the player conquer even more hidden quests. In order to finish these quests, the player must also spend hours leveling up their characters, which typically involves finding the most rewarding monsters and repeatedly beating these monsters. Assassin's Creed

also offers a number of side quests. These side quests reward the player with wealth and items required to upgrade their weapons. They also act as part of a collection. When players finish all side quests of the same kind, they are rewarded a trophy visible by their friends through console-based social networks. ***Bioshock Infinite*** does not have a side quest system. Instead, the game allows the player some level of freedom on the game map, so that the player can walk around picking up additional loot, or go back to an old scene when they have acquired a key to unlock a previously locked safe. The rewards are usually minimal, but as large sums of such rewards accumulate, the players feel an impact in their character's progression, and may consider it worth their time. Visual novels typically use a considerable amount of story to extend the length of game play. Some visual novels do allow the player to wander in different places as part of the process of advancing the story, such as in Ace Attorney, where the player is required to arrive at different scenes in different orders to acquire evidence to present to the court. The mechanism of allowing the player to investigate different scenes in a visual novel can be applied to an existing story with minimal effort on expansion. Thus this technique will be employed in this work.

Agency: In addition to the MDA framework mentioned above, there are other theories developed to guide towards an engaging game experience. Among these theories, the concept of agency has been considered an important goal of modern game design (Murray 1997). There are two types of agency: local agency means a game responds to every player action with an immediate feedback, such as making the player's spaceship shoot a laser beam whenever the player presses the right button; global agency means a game alters later parts of the game based on major decisions the player makes early on, such as in many visual novels where each choice the player character makes will lead to a different path of the story. When combining a game with a health intervention, local agency can be achieved by allowing users to make choices for characters in the story or by providing feedback to the user's homework completion status, and then altering the immediate storyline to reflect the user's choices or homework performance. Achieving global agency will require the game to be arranged in such a way that reflects the user's choices within a large time scope, potentially several days or weeks. Games with multiple choices typically branch into different paths based on player choices in the story. This can be as small as the player acquiring a resource,

or as grand as the player engaging an alternative route and ending of the game. Here, a few possible approaches to branching is recommended:

Local branching: At a point of branching, based on player choice or, as in the prototype game in this dissertation, the player's homework performance, characters in the story can be awarded an item, granted an ability, or given guidance to a solution. This temporary solution may have a small impact on the story immediately, so that the character can achieve whatever goal they're trying to achieve easier or better. Once the solution has had its impact, the item or ability will be eliminated from the story. For example, in the visual novel Never 7, the player must play the game multiple times to beat it. During each of these walkthroughs, the player will make several choices. The player's choices will affect the relationship between the player character and the NPCs, affecting the characters' mood and altering how the story progresses on a small scale. This is local branching. At a later point in the walkthrough, the player character's relationship with other characters will be analyzed to determine which ending the player will receive. This is an example of global branching, as explained below.

Global branching: At a point of branching, the user choice or homework performance will influence whether characters in the story will be given an item, a solution or an ability that has a long-lasting impact. As an example, in Dragon Age: Origins, the player's decision regarding what to do to their potential allies will determine what type of reinforcements they have when they eventually face the villain.

Choose your own adventure: Choose your own adventure is a type of story that is highly customizable based on the player's choices. Each player choice can potentially lead to a story completely unrelated to the stories that would be presented had the player chosen otherwise. An example in the form of video game is A Duck Has an Adventure, an Android app featuring the story of a duck with many player choices. This type of video games is difficult to develop due to the strong requirement for content development.

4.2.3. Methodology for Incorporating engagement techniques in a health game

One problem unique to narrative-based games for health is how to integrate the health intervention into the game's story coherently. The majority of games for health have chosen to develop stories featuring characters with problems in the health behaviors in questions. For example, ***PlayForward***, a visual novel type of game with minigames integrated aimed at providing young teens with the knowledge and skills necessary to avoid engaging in behaviors that increase their risk of contracting the HIV, contains several chapters of stories featuring young teens battling a variety of problematic behaviors at school, such as cheating in an exam, and refusing peer pressure (Duncan et al. 2014). As another example, ***QuitIT***, a game aimed at enhancing coping skills for smoking, uses several short stories where the player character must help themselves or others resist the urge of smoking (Krebs et al. 2013). The stories in these games serve an inoculation therapy of sorts, providing the players opportunities to rehearse possible scenarios, where the player can develop coping strategies in a safe environment.

This approach of story writing has two major issues. First, players rehearsing a behavior in a virtual environment may not carry the behavior to the real world. For example, a player may enjoy running miles in a game world, if the game's mechanisms makes running in the virtual environment fun, while the player may be willing to perform no physical activity in the real world. This is especially true toward the later phases of behavior change in the Trans-Theoretical Model, where the individual has acquired sufficient knowledge on the subject matter and must actively engage in behavior change. Second, stories developed only for the purpose of discussing a behavior may lack a well-defined premise. A premise is a story's purpose, moral, or theme, which is a philosophical idea that holds true across cultures and times (Egri 2007). A story's premise is reflected throughout the story in different places, and it is difficult, if not impossible to engage a broad population with a story that does not have a sound and interesting premise. Determining the premise is often the first step of story writing, and it is important that story writing for health games follow this approach, if one aims to create engaging stories for these games.

Therefore, instead of creating a story surrounding the theme of health behavior change, in this work I propose a different approach to story writing in games for health, specified in the following three key steps.

Step 1: Writing the basic story.

The game writer starts writing a story because they have an idea to express, and they would like to deliver the message through a story. Thus the story is written as if it is for a commercial game, delivering a premise that the player can resonate with. Methods to come up with good premises can be found in the play writing literature, such as (Egri 2007). The game designer can also choose a story written by an external source, as I have done in the game described in Chapter 5, in which case the story may or may not have a sound premise. The game designer must make a judgment of, or conduct research to find out, whether the story has a good premise. If not, the game designer must modify the story so that a good premise can fit it. The methodology for adapting an existing story will be covered in more detail in Section 4.5.

Step 2: Weaving behavior change into the basic story.

Once the game's basic story has been formed, the intervention for the target health behavior change needs to be integrated into the story: the player may be asked to engage in behavior change to advance the story or as part of the plot, and the connection between the player's behavior change and the story progression must be logically coherent, or the story's believability can be damaged quickly, and the player will lose interest in the story. The premise of the basic story can be revised to make way for an easier integration of health behavior change, and if so, the game designer can revise the basic story accordingly as well.

Step 3: Anticipating player behavior.

In a health game developed for long-term behavior change, the player's stage of change may or may not change during the course of the game play, and if it changes, each player's speed of progression may be different. The game designer may choose to take into account the possible change or stagnancy of the player's health behavior change, and consider how the game's story

should be adjusted in response to different patterns of player behavior. This is an optional step, but it may help the player to perceive the impact of their real-world behavior in the story, thus serving as reinforcement to the player's game play, making the player more engaged in the game and adherent to the intervention.

4.3.4. Further questions for the designer

The above techniques of engagement answer the critical question of how to make a health game enjoyable to the player. However, a few critical questions must be answered in the specific context of the game's story and setup, as both a review of legitimacy of the choices to apply or not apply each engagement, and as an opportunity to further immerse the player in the game world. The DraGuNa framework therefore recommends that a game designer create a basic game following these guidelines of engagement and incorporate the intervention part into the game, before revisiting the following questions and making final decisions of the engagement techniques to employ.

1. What is the player's role in the game?
2. What drama techniques are used in the game, and how is each technique integrated in the game?
3. How is branching achieved in the game, if any?

I will discuss the answers to these questions here, and offer more explanations in an example game's context in Chapter 5.

Question 1: What is the player's role in the game?

Since the basic story should have been written at the point this question is asked, the player's role in the story should already be more or less determined, but the game designer must still consider how to implement the role in the game. This typically entails two generic questions:

1. How does the player character interact with other characters?
2. How does the player character interact with major goals, objects and forces in the story?

A typical game mechanic involving interactions in a game is to let the player control the flow of his or her conversation with the different characters in the story, and to determine the kind of power the player has by his or her relationship with these characters. The implementation of this mechanic will involve allowing the player to make choices during certain interactions with non-player characters and other objects and forces, and scripting meaningful feedback based on these player choices. Essentially, this approach requires a system that affords branching: the method of recording every important player choice and using conditional clauses to determine the story immediately following the player choice or some time further into the story. In order for the branching to be engaging, the choices that the player makes must lead to meaningful consequences in the story, and considering the two key questions that I seek to answer, in my prototype, I've chosen to let the player's homework progress affect the way he or she interacts with the characters and atomic energy.

To make things simpler and easier to manage, the game designer can also choose the use a low-interaction approach in a game. The approach is prevalent in visual novels, where the player typically clicks through the story. The story can still be engaging if done right, but to do so requires much more experience in both story-writing and game design. Eventually, deciding how the player interacts with the game's environment is a matter of agency: how much local and global agency does the game afford is determined by the types of interaction the player is allowed in the game.

Question 2: What drama techniques are used in the game, and how is each technique integrated in the game?

For a story to be successful, the writer must be able to command as many drama techniques and use them as properly as possible. Earlier in this chapter, I have listed several drama techniques that are commonly used and have been applied in intelligent narrative systems. All of these techniques can be applied methodically through the story in the writing stage, but some techniques can be applied dynamically, based on the player's behavior in and outside of the game.

In Section 4.4, I will discuss an algorithm that applies two drama techniques dynamically. This can serve as a starting point for game designers who wish to integrate drama into their health games in a way that depends on the player's behavior and potentially reinforces desired behaviors.

Question 3: How is branching achieved?

A most basic branching mechanic, used in the majority of commercial games, is for the game to allow the player to make multiple choices and choose a pre-determined path of story progression based on the choice. In a health game, a good reason for employing branching is to allow the player to make an impact on the story based on whether he or she completed the homework, and creating both local and global agency. In a commercial game, a likely approach is to set a "flag" after a player completed or abandoned each homework, and the flag will be used to determine if a certain branching path should be selected by hard-coded scripts. To create global agency, earlier flags will influence the later stages of the game, and multiple flags may interact to branch into distinctive story paths. Under this approach, the amount of content needed increases exponentially as the number of player choices increases. This method also suffers from the low probability of each story path being experienced by a player, and thus it is hard to argue that the amount of effort spent on writing the branching scripts is worth the while. Game designers on large projects tend to keep the number of critical branching small, so that the amount of writing does not grow exponentially. Game designers can also focus more on local agency and ignore global agency until the very end of the game, which is an approach taken by the Dragon Age series. Under this approach, the main story line remains linear, and the player still achieves a sense of control.

4.4. Achieving engagement and adherence using intelligent narrative

In Section 4.2, I discussed that motivation techniques and reinforcements can be tailored to each player, and in Section 4.3, I discussed different ways to achieve branching in a story, and the possibility that drama techniques can be applied to a story dynamically, based on a player's actions in the game or on their homework progress. As part of the DraGuNa framework, I explain the use of a piece of intelligent narrative technology, a **Narrative Selector**, to implement these methods.

To explain the mechanics of the Narrative Selector, let us examine an important concept in this algorithm: a **satellite story**. A satellite story is a chunk of story that is related to the main story but is not necessary for the story to progress. Satellite stories are used in many commercial games to prolong the game-play, and in some games, to reveal additional information that the writer would like the audience to receive. A satellite story is the basic drama unit that the Narrative Selector manipulates, similar to a beat in the Façade drama manager. A satellite story is longer than a beat, in that a beat is usually one exchange of conversation, while a satellite story can entail multiple exchanges of conversation, and a number of advancements in the story. I chose to work with satellite stories as the basic drama unit because it is quite easy to maintain the integrity and consistency of the story by inserting satellite stories compared to manipulating smaller units such as beats. Multiple satellite stories on the same topic can be used to build a **satellite story line**, where the dramatic tension increases with each satellite story told.

The primary function of the Narrative Selector is, as its name suggests, to select a satellite story at certain spots of a game. These spots can be when a motivation technique is needed or when a reward needs to be given to a player, and these satellite stories can serve the purposes of applying drama techniques, and to branch the story thus achieving agency. The following algorithm, AddStory, describes the mechanics of the Narrative Selector.

Algorithm AddStory:

1. toFollow = the type of satellite story requested at the current position, depending on the player's actions in the game or progress in their homework assignments.
2. keys = current conditions that must be met.
3. storySet = find all satellite stories whose category matches toFollow.
4. chosenStory = find satellite story in storySet that meets all requirements in keys and has highest priority. (priority is determined by the progress already made on each satellite story line: the more a story line has progressed, the higher the priority)
5. priority of chosen satellite story line += 1.
6. return chosenStory.

This algorithm leaves a lot of space for a game designer to customize his or her own Narrative Selector. For example, a game designer may decide that only a player's homework performance influences the choice of toFallow, or the designer may require that a certain character must be present around the player character when a satellite story surrounding that character can be presented. As another example, the algorithm also allows for the construction of a feedback loop as illustrated in Figure 4.4, above, where the completion of a character arc leads to a more significant reward. This can be achieved by assigning satellite stories further along a satellite story line a higher priority, and changing a condition required for a significantly rewarding satellite story at the end of a satellite story line.

In summary, this algorithm can be used to function as a central mechanic to be triggered whenever a satellite is needed. A typical homework-based health game session using the Narrative Selector can be illustrated by Figure 4.5.

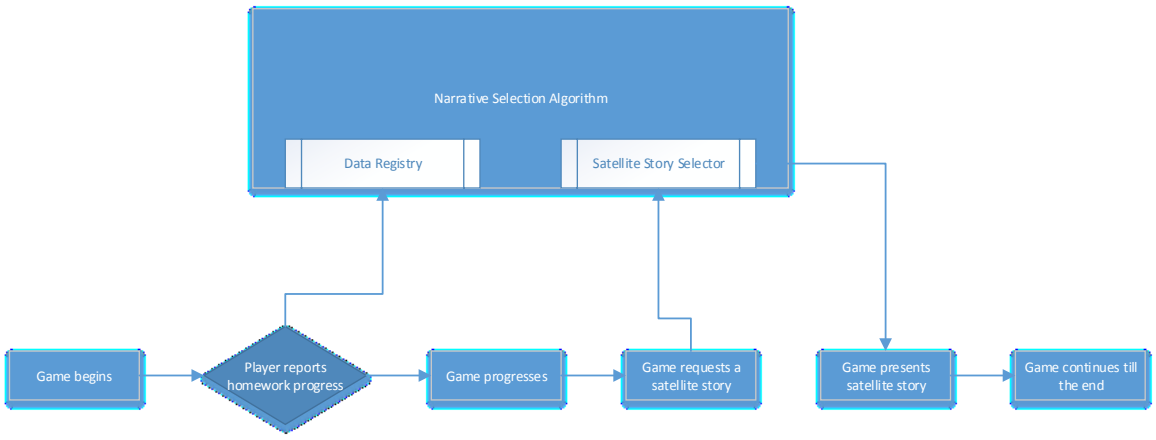

Figure 4.5. A typical homework-based health game session using the Narrative Selector

In Chapter 5, this algorithm will be reviewed in the context of an example game to demonstrate the customization process.

4.5. Methodology for Adapting Existing Serial Stories for the DraGuNa Framework

Although game designers may want to write new stories for narrative games for health, there are many situations in which developers may want to design their game around an existing story or serial, for example, to brand a game with an existing commercial series, or to minimize the time and cost of game development. Before delving into the development of an example game, I will discuss a methodology for re-purposing existing story content for a narrative-based health promotion game. Let us review the details of the process of using a third-party story in the DraGuNa framework. The chapters that follow will be centered on a game created in the manner elaborated here. The procedure recommended in this work follows three steps: choose the story, adapt the story, and incorporate intervention.

Step 1. Choose the story

When a game designer decides to adapt a story, he or she may begin with a relatively large repertoire of stories to choose from. The story may take on a variety of forms: novels, comic books, videos, or even existing video games, as long as the designer has a way of reusing the materials in the new game. Roberts' study is a good example of reusing videos to create a game for research purposes (Roberts et al. 2009). It is the game designer's job to determine what medium to look at and how to make use of the materials from the medium. The easier it is to reuse materials from a medium, the more original work is required to create a playable game from these materials. For example, stories from novels are relatively easy to adapt, but original art work, sound effects, and possibly music and voice casting are required before a playable game takes form; on the other hand, existing games can be used for a study immediately, because these games are already in playable format, but to change the story even slightly requires access to the game's code, or some way to extract the various art and sound files and rearranging them using a re-written game architecture.

Although the majority of games for health chose to use a story closely tied to the health behavior, this approach may be more effective towards players in later Stages of Change. If an individual voluntarily plays a health game without prior knowledge of the health intervention, especially if the

individual is in earlier Stages of Change of the target behavior, it is advisable to choose a story unrelated to the health behavior so that the health message remains unobtrusive (Slater et al. 2003). However, to remain relevant to the behavior change intervention, the story may contain one or more characters that exhibit the behavior, who also play important roles in the story.

When choosing the story, the designer must also pay attention to the length of the story, the quality of the story, and the size of the target audience who has already read the story. It is difficult to find a story that is both well-written and unknown, for well-crafted stories tend to receive attention and become wide-spread. If a gem truly remains hidden, the designer has to be lucky enough to be introduced to the story in some way. In some cases, using a well-known story does no harm to the game's purpose, and perhaps may even increase the player's engagement with the game, but otherwise, I recommend looking for a story with relatively high quality and less well known to the general public so as not to bore the audience.

Step 2. Adapt the story

Once a story is chosen, the designer can read through the story several times to understand the story's structure and each major character's progression throughout the story. The first step of adapting the story for the purpose of the game is to construct a background story for each main character. These background stories should be self-consistent, and should help justify the actions and choices of each character in the original story. For instance, if a game designer were to adapt the story of Batman: Dark Knight Rises (2012), the designer must rewrite a major part of ***Batman Begins*** (2005) and the small portion of ***Batman: The Dark Knight*** (2008) that relates to the death of Rachel and Harvey, because only with the prior stories can Batman's actions in the final chapter of the trilogy be justified.

The game designer can then edit the story to make it suit the game's context better. This includes adding details that are relevant to the story's premise, removing segments of the story that are irrelevant, and editing the length of the story and deciding the length of an average game session to fit the desired length of the health behavior intervention, etc. The purpose of the editing is three-

fold: 1) it can increase the player's engagement with the game, 2) it can smoothen the integration of the behavior intervention, and 3) it can help the designer define the role that the player character plays in the game and make the player's relationship with the game more interactive. Once these background stories are developed and carefully edited, the game designer can draw satellite stories from these background stories. The satellite stories can be reflections of the past, or non-player characters' confessions, regrets, or inspirations related to their past.

Once all editing is in place, the designer ought to also identify potential places that can relate to the health behavior change intervention. As mentioned in Step 1, if some of the characters exhibit the problem behavior or are exemplars of a desired behavior, these characters can easily serve as a pivot to deliver the intervention messages. If the player character can perform certain tasks in the game that relate to the health behavior, an emphasis may be placed on the player character's role.

Step 3. Incorporate the intervention

At this point, the game designer should have a behavior change intervention ready to be integrated into the game. The intervention can take on the form that is used in this dissertation, namely a daily homework system, or some other form that can be proved to work. The game designer then defines how the player will be involved in the intervention, and how the player's actions will impact the progress of the story.

In the following chapter, I will discuss a prototype game designed using the DraGuNa framework. The story of the game is adapted from a 1950s comic book, by following the three steps listed above.

Chapter 5. Example Game: Adventures of the Atomic Submarine

In this chapter, I discuss a computer game I developed following the above methods to promote physical activity. The game has a heavy emphasis on narrative, following the DraGuNa framework, to improve the player's engagement with the story and adherence to the homework, and the

Narrative Selector has been adapted to the game's context to serve the purpose of providing tailored stories, reinforcement and engagement. The intervention part of this game was created based on the principles of Trans-Theoretical Model, using homework assignments to promote physical activity described in Appendix A. A list of the Processes of Change, their corresponding Stages of Change for physical activity interventions, and a sample homework assignment for each Process of Change, developed for the intervention in this thesis, are listed in Table 5.1.

Process of Change	**Stages of Change**	**Sample Homework**
Consciousness Raising	PC, C	Search for online articles about the pros and cons of physical exercise.
Dramatic Relief	PC, C	Reflect on movies or TV shows you've seen and think of one character who could benefit from exercising.
Environmental Reevaluation	PC, C	How would the society change if more people exercise regularly?
Social Liberation	PC, C	Ask two friends about their opinions of exercise. Do they know that exercise is good for them?
Self-Reevaluation	C, P	Imagine that you are exercising regularly. Will that make you happier?
Self-Liberation	P, A	Think about an exercise goal you want to reach by the end of the year. Make it a New Year's resolution.
Helping Relationships	P, A, M	Find someone you can trust. Ask them whether they can play the following game with you: at the beginning of each week, tell this person your weekly exercise goals and give them a small amount of money that you would feel bad if you lost. At the end of the week, if you meet your exercise goals, you may take the money back. Otherwise, your trusted person will keep the money.
Counter Conditioning	P, A, M	In the afternoon or after work, when you feel tired, take a walk instead of taking a nap. See if that makes you feel better.
Reinforcement Management	A, M	If you meet your walking goal for the week, treat yourself with a frozen yogurt, cook yourself something nice, or get yourself a gift that you wanted to have for a long time.
Stimulus Control	A, M	Put on special clothes suitable for exercising when you go for a walk. Put these clothes in a place where you can easily see and access.

Table 5.1. Sample Homework Assignments for Physical Activity Promotion

5.1. Story Choice

The game, *Adventures of the Atomic Submarine*, is adapted from *Commander Battle and the Atomic Sub*, a cold-war-themed comic book series considered to be created by *Richard E. Hughes*

and *Sheldon Moldoff* and published by *American Comics Group* in 1954 and 1955. The comic book genre was chosen because it is a balance between ease of reuse of materials and ease of story modification: the frames of a comic book can be cut off and rearranged, and the texts from the comic can be edited to give the story a new meaning. The particular comic book was chosen because it is a balance between quality and fame: for a story not well-known to the public, I chose public domain comic books as a main source of search, and among the public domain comic books available, Commander Battle and the Atomic Sub was one with relatively good quality, whose writer would later create Marvel's *Dr. Strange*, and whose artist would later become a ghost artist for *Batman*.

To create this game, the original comic book was modified to create a new story. A game interface was created so that it becomes easy for the player to go through the comic book on a computer, that homework assignments related to physical activity can be assigned to the player, and that players can report their homework progress in the game. An underlying algorithm was also developed to apply several engagement and homework adherence techniques discussed above in the game. Figure 5.1 is a snapshot of the main menu of the game.

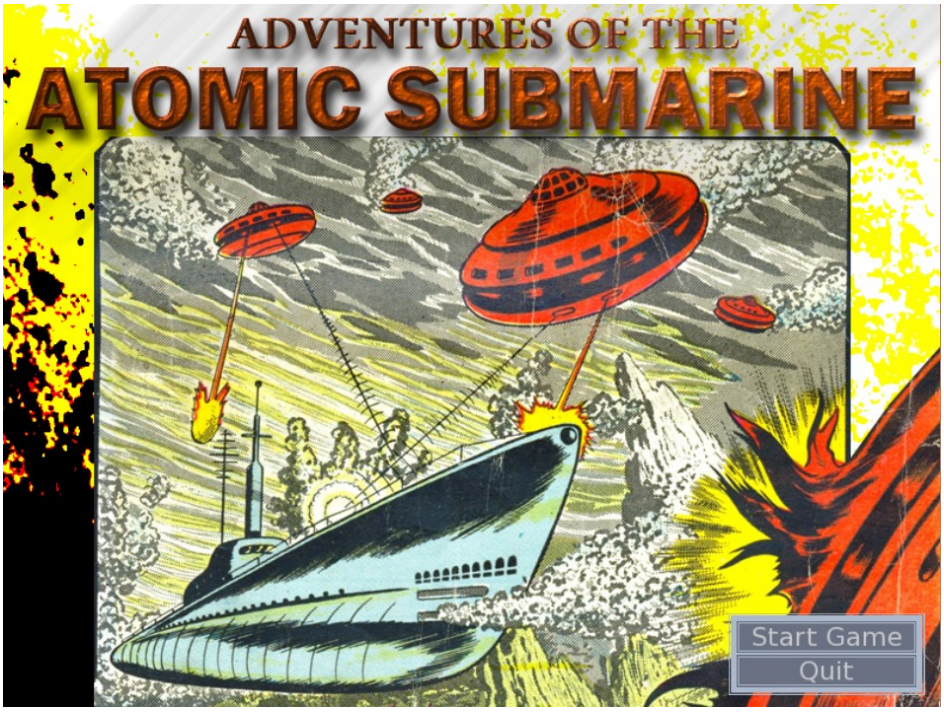

Figure 5.1. Main menu of Adventures of the Atomic Submarine

5.2. Story Adaptation

The story of Commander Battle and the Atomic Sub is about a group of America's most talented individuals being summoned by the President of the United States to pilot America's first atomic submarine to prevent catastrophes from befalling the States and the world. The group, a.k.a. the atomic commandos, consists in the beginning of World War II hero and ex-secret service man Bill Battle, the physically strongest American David B. Ruggles ("Champ"), scientific genius and expert in many fields Dr. Edwin Blake ("Doc"), and the escape artist known as "Gardello the Great", Tony Gardello ("Tony"). The group would be later joined by a teenage boy and young genius inventor Jonathan Flint ("Jonnie") and Tony would die in a battle.

Seven issues were published, each containing an independent story surrounding the atomic commandos and the atomic submarine. The detailed descriptions of the content of these issues can be found in Appendix B.

Overall, the story has two major issues. First, the story does not have an overarching plot, and the stories in the seven issues have very little connections among one another. This is possibly because the series was terminated early (http://www.toonopedia.com/atomsub.htm). Second, the story lacks a good premise (Egri 2007), which may be partially due to the first issue mentioned above, and partially due to the fact that the comic series was created during the Cold War and was limited to the views of its times. Therefore, to adapt the story to a game and to make the game engaging for the modern audience, the first step is to give the story a premise and an overarching plot.

In addition to a premise, what role the player is going to play in the story must also be considered. Because the comic book's existing characters already have their roles coherent with the story, I've chosen to create a new character, an additional atomic commando, to act as the player character. And because the comic book pages were adapted directly to the game, I've chosen to not allow the player character's face or body to appear in the picture throughout the game.

A few themes naturally emerged from the seven issues of the comic book: one who abuses power becomes the target of vengeance; one who chooses to destroy will be destroyed; one who uses technology makes it good or evil, as a few examples. After iterations of storyboarding, a premise was chosen: what is used to destroy can be used to protect. The story was then modified to reflect this premise. In particular, the story was modified in the following ways:

1. The player character was created to be a main character in the story. The player character's true identity was designed to be a superior soldier created in World War II, through combining atomic technology and the human body, namely *the atomic soldier*. The atomic soldier was in fact created to prove the concept that atomic energy can be used for peaceful causes, in order to make the proposal of creating atomic bombs politically sound. The atomic soldier therefore preceeded the Manhattan Project, and was deployed in war zones in the last years of the war. During this time, the atomic soldier came to know Bill Battle, and due to both of their outstanding performances, they became ace pilots and sent on the most dangerous missions. At last, the atomic soldier and Bill went on the mission to escort the bomber that delivered the atomic bomb in Hiroshima, but unfortunately, they were both shot down and involved in the explosion. The atomic soldier created an energy shield that protected Bill from the explosive concussion, the heat and the radiation that lingered. However, the atomic soldier, exhausted from the effort, sunk into the depths of the Pacific Ocean, until now, at the beginning of this story, the soldier was found again on California shore, with all memories lost. Sensing the intensifying heat between the United States and the Soviet Union, the President of the United States decided to designate the atomic soldier as an atomic commando, sent on missions with the atomic submarine in the hope of restoring the soldier's lost memories and lost powers.
2. A non-player character was added. The character added was a historical figure, Dr. Julius Robert Oppenheimer, and it was done to explain the player character's identity in the story. In the grand theme of this story, Dr. Oppenheimer was the creator of the atomic soldier, and he created the atomic soldier to prove that atomic energy can be beneficial to humanity, before he delved into the Manhattan Project to create the deadliest weapon in human history. However, the character would not appear directly in any part of the story. In the 1950s, when the story

takes place, Dr. Oppenheimer was being accused of ties to the communist party, and he had fallen from grace on the political stage, so in this story, he only appeared as a friend of the President and an ally of the player character, and would give the player character a few letters through the President, which would partially reveal the player character's past. In other word, Dr. Oppenheimer was added to help unravel the player character's identity, which helps to reflect the story's premise. To strengthen the character's impact in the story, I also added connections between Oppenheimer and two other characters: Dr. Edwin Blake and Jonnie Flint. Dr. Blake would refer to Dr. Oppenheimer as an old colleague and rival, who was faster in proving the atomic bomb was practically possible. Jonnie Flint would refer to Dr. Oppenheimer as a relative who told the boy countless stories of the atomic soldier, which motivated him to join the atomic commandos. These connections were made to make the character more believable.

3. Satellite stories were created surrounding each of the non-player characters following the method described in Section 4.5. Two types of stories were created for each character: transition and foreshadowing. Several satellite stories were written about these characters, which build on top of each other to transform a character from one quality to another. These satellite stories are categorized into transition stories, which transform a character in a positive way, and foreshadowing stories, which transform a character in a negative way. For example, Tony's transition stories would transform Tony from a man who knows only to escape from his responsibilities to a man who upholds his duties. On the other hand, Tony's foreshadowing stories would bring Tony to realize that he's been running away from his responsibilities all his life, and he's grown tired, but he has no desire to make things any different, which will eventually lead to his death in the middle of the story. These satellite stories typically involve a non-player character discussing his past with the player character. These stories emerge from the background stories I've created for each of the non-player characters. The background stories are presented below. Note that Bill Battle's name has been changed to Bill Tyler to make the name sound more believable in our age and context.

A list of characters that appear in the revised story and their background narrative can be found in Appendix C.

After the main story has been revised and the satellite stories have been written, I proceeded to Step 3 described in Section 4.5 to integrate health behavior intervention to the story.

5.3. Intervention Incorporation

After the story was revised, I proceeded to integrate the physical activity intervention outlined in Appendix A into the game. However, two questions must first be answered regarding this intervention: 1) what form does the intervention take, and 2) how is the intervention coherently integrated into the story?

In Adventures of the Atomic Submarine, the player will receive a homework assignment tailored to their physical activity stage of change at the end of each game session; the player will be given time to complete the assignment before the next session; and when the player logs in to the game again, he or she will report the progress on the assignment.

Since the form of the homework assignments has been decided, the question that remains is how to integrate these homework assignments into the story. For this purpose, I examined the player character once again, noticing that the reason for the player character being in the game is to recover her lost memories from World War II, so that she could save the country in an imminent catastrophe. It was clear that an easy way to integrate the homework assignments is to claim the player character doesn't only need her memories, but also her strength, and thus performing certain tasks to improve her physical conditions will make sense. However, a player may question the motive behind having the player character recover her strength, unless it is made clear that the player's strength is necessary to perform the miracles she had done to save Bill in Hiroshima. Therefore, I added another layer to the player character's background story, summarized as follows:

The Atomic Soldier

The atomic soldier was a regular soldier who suffered a slight injury during World War II. During his or her treatment, the soldier agreed to an experiment that would alter her body. The experiment

was conducted by Dr. Julius Roberts Oppenheimer as a prototype of atomic weaponry. The result of the experiment was a fusion between human and atomic energy, an unstable being capable of absorbing and influencing energy around her. The prototype was used to convince the President to commence the Manhattan Project, and the soldier was sent back to the battlefield shortly after to test her abilities to retain her regular physical functions. When the atomic bomb was created, the atomic soldier was assigned to escort the bomber that would deliver the bomb to Hiroshima. On the same mission was her veteran friend Bill Tyler. During the mission, they were both shot down by the Japanese air force and landed on Hiroshima. They were inevitably caught in the middle of the explosion, but just as Bill thought he was certainly dead, he woke up to find himself well and alive. He could not find the atomic soldier, so he assumed she was dead, not knowing the atomic soldier absorbed the atomic energy from the explosion and protected Bill as a shield. However, the atomic soldier absorbed too much energy and radiation, so she fell unconscious and sunk to the depths of the Pacific Ocean, where her extraordinary physical functions healed over the next few years. When the soldier was discovered again, America was in the dire Cold War against Russia. The President, hearing the miracles that happened in Hiroshima, wanted to use the atomic soldier as a shield should a nuclear strike be initiated by the Soviet Union, but the scientists concluded that the soldier has not recovered enough to use her atomic powers. What's more, the atomic soldier has totally lost memories of who she is. Therefore, the President ordered that the atomic soldier be sent on missions on the newly developed atomic submarine, so that the atomic energy from the submarine's engines could help the atomic soldier's memory and physical recovery. The President also asked the scientists to design a set of exercises to help the atomic soldier to get back into shape.

This background helps form a reason for the player to perform physical activity related homework: to help the atomic soldier, i.e. the player character, regain physical strength and memories. Note that the above story was created after several iterations of brainstorming and storyboarding, and because the basic story was already rooted in a historical setting, I borrowed historical events and historical figures to add vigor to the story. The basic story was also a sci-fi story, so adding more sci-fi settings that are coherent with the already existing story would add to the overall believability

of the story. Should the story be written in a different genre or setting, the story writer must apply different techniques that are appropriate to the story.

5.4. Engagement Techniques

Now that the basic story of the game and the basic game architecture have been developed, I will discuss the application of engagement techniques described in Section 4.3 above to the game and how the game's architecture is used to support these techniques. First, let us examine how the drama techniques are applied in this game.

Suspense: In the original story of Bill Battle and the Atomic Submarine, suspense is used within the scope of each of the seven stories, and therefore in the game of Adventures of the Atomic Submarine, suspense appears in most episodes that would lead the player to wonder what happens next. When I modified the story to add the player character's interactions with NPC's and with atomic energy, suspense is often built up as well, in some of the satellite stories, so that the player would wonder what will happen to these NPC's. In practice, each NPC has his own story arc, and the player must complete a prerequisite satellite story of a particular NPC before reaching the character's later story pieces. In addition, the player character's ability to interact with atomic energy also creates suspense as this power slowly reveals itself as the story unfolds. During the player's interaction with some NPC's, the characters mention their understanding of atomic energy, and even though these characters may not fully understand the player character's source of power, they notice that the player character's strength can influence the performance of the atomic submarine, and some characters will give the player character advice on how to use his or her power. As the story progresses, the player character will have the opportunity to save the life of an atomic commander, where the player will discover what the atomic soldier's power can do. Eventually, the player character gains back his or her full power at the end of the game, and saves the world by neutralizing the atomic explosions that would have meant the end of the world. Each time a chunk of story relates to atomic energy, it reveals one aspect of the player character's power, thus leaving the player curious about the full story.

Characterization: This process overlaps with transition and foreshadowing, and in the original comic book, certain degrees of characterization exist. For example, in the original comic book, each atomic commando has his own character and specialty: Champ is a wrestler, a tough guy who like to solve problems with force; Doc is a scientist, a smart guy who always comes up with clever ideas; Tony is an escape artist, responsible for getting the commandos out of any jail, and has to hide his low self-esteem with overt optimism; Jonnie is a prodigy at a young age, working hard to be recognized as an adult; and Bill is the most resourceful and responsible man you'd ever meet. These are not as complicated as in a good modern drama, but in my modified version, these characters' personalities have been expanded based on their original version. In the new Adventures of the Atomic Submarine game, the characters' personalities are multi-faceted as noted by Freeman (Freeman 2004), and these personalities are often demonstrated through the transition and foreshadowing stories. For example, in Tony's foreshadowing story, he shows despise for the player character because he thinks the player character is an entitled prick who doesn't work as hard as he does, which is rooted in his life as a helpless child who had to fend for himself. On the other hand, in Tony's transition story, he explains why he is working hard for the atomic commandos: that he is in love with a woman and has decided to stop running away from his responsibilities.

Tragedy: Tragedy is used in various places in the original comic book. For example, Tony Gardello, when protecting an American scientist while the other atomic commandos were poisoned and fell asleep, was murdered by Russian assassins. When the atomic commandos reached Tony, he had only enough strength to leave his last word. In the game, these tragedies are presented as they are, but in this particular case, the player has the chance of saving Tony's life, the condition being that they have completed sufficient homework assignments up to the point of the game where Tony would have died.

Movement: Movement exists in the original comic book. In a typical story, the atomic commandos would investigate a sudden phenomenon, and while they crawl through clues to identify the culprit behind a sinister plot, they often face defeat in the form of severe damage to the atomic submarine, imprisonment, and a deadly threat of world destruction. Due to the presence of movement in the

original comic book, I have decided to introduce no further movement in my satellite stories, although movement could be one more way of further improving engagement in the player.

Fantasy: Created in 1953, the comic book Bill Battle and the Atomic Submarine is a work of science fiction, but viewed from the present day, it may be considered a retro-futuristic story. Retro-futurism is a trend in the creative art showing the influence of depictions of the future produced in an earlier era (http://en.wikipedia.org/wiki/Retrofuturism). Some parts of the story has become out of date and seems less believable. Certain descriptions of physics are completely wrong due to a lack of scientific knowledge available in 1953. Certain depictions of Russians are over-stereotypical. I've corrected the scientific mistakes that appeared in the story and modified the story so that the plots to utterly destroy America are, instead of works of the Russian government to establish their world domination as in the original comic book, become plans laid by the GRU, an independent intelligence agency in the Soviet Union. In addition, since the player character has the supernatural power of manipulating atomic energy, I added in the story that the player character fully recovers his or her power in the last episode, forming an energy shield around his or her body to protect the United States from a nuclear strike initiated by the GRU, after which the player character loses consciousness again, just as he or she did before the beginning of the story, saving Bill Tyler from the Hiroshima atomic bomb. These changes should all serve to increase the believability of the story, thus improving the player's engagement.

Challenge: The story hardly provides the player with any challenge, but the homework assignments, or missions, as called in the game, which the player is assigned to do, which are related to physical activity, serve as a challenging part of the game. The difficulty of the missions vary, but the missions are all tailored to the player's current physical activity level, and the completion of each mission is rewarded in the game through a piece of satellite story, as controlled by the Narrative Selector.

Discovery: The original comic book provides many sites for discovery, from underwater cities established by invaders from Mercury to giants and fish-men dwelling in the center of Earth, and from an ancient race sleeping beneath the Arctic icebergs to a highly lawful civilization on the Moon.

The satellite stories in the Adventures of the Atomic Submarine story add a few more things for the player to discover. These satellite stories focus on the NPCs' personal background and growth, as a compliment to the original story.

Expression: The original story provides very few opportunities for the reader to feel expression, except for the moments that the atomic commandos had to destroy an entire civilization to protect humanity after failed negotiations, which add a dark tone to the story. The satellite stories I added in the new story offer more expression to the players. By understanding the NPCs' personal stories, by getting to know how they ended up an atomic commando, and by hearing their ideals and life's goals, the player may empathize and sympathize with the NPCs. The new ending of the story, where the player character falls unconscious after protecting America from a nuclear strike, and wakes up again decades later, implies that although technology advancements have made life easier for humanity, the same history still keeps repeating itself, and the decisions that humanity has made are no better than hundreds and thousands of years ago. This ending may provoke the players to think, and thus serve to add expression to the game.

Submission: A good comic book provides content that engages the user, that makes the reader want to read more, and that allows the reader to kill time by reading the story. The seven issues of the original comic book provides a certain amount of submission, but a critical question is will the modern-day audiences find the story engaging, and what subset of the audiences will find it so? This will be an important question to ask in the evaluation study to be described later in this dissertation.

Apart from the use of these techniques, let us also examine how the three key questions of engagement for the game designer can be answered in the game's context.

Question 1: What is the player's role in the game?

To answer this question, a game designer must consider how the player character interacts with other characters, and how the player character interacts with other major objects and forces in the game. In the case of Adventures of the Atomic Submarine, this converges to the following questions:

1) how does the player character interact with other characters? And 2) how does the player character interact with atomic energy?

The player character interacts with the other characters mainly through hard-coded scripts in the story, but the player can impact the other characters by choosing to complete or fail their homework assignments, as moderated by the Narrative Selector, discussed above. I aim to create two types of agency through this mechanic: local and global, meaning the player's actions will have both short-term and long-term effects in the story.

To create local agency, the NPC's in the game must respond to the player's homework progress immediately in each session. In my initial design, I created a simple function that creates a branch in the story that can lead to two different paths, which would later converge back into the same place further in the story. However, to make the implementation more flexible, in the end product, I changed the function into an algorithm that picks the most appropriate branch from a list of options before converging back to a set point further down in the story. This allows the program to potentially branch into more than two paths and to take into account more variables that the game designer has added when deciding which path to take, making it easier to implement global agency.

To create global agency, the branching paths were designed to be continuous: three or four satellite stories were created as a group, which would be presented to the player in a particular order on a given branching path. For example, the three-piece story that deepens the player character's relationship with Champ David Ruggles follows such a flow: In the first story, David shows his respect for the player character and promises to show the player character a gym that he built on the submarine; in the second story, David leads the player character to his gym and reflects on a memory where his best friend was killed by a German spy and he killed the spy in revenge, and that even though he is America's strongest wrestler, he still thinks himself weak in the mind; in the third and final story, David explains to the player character that he is no longer troubled by the regretful memory, because he's seen the player character's strong mind in spite of the utter loss of his or her memories. These stories will play out in the course of three game sessions, should the player make the choice that leads to these stories.

Similar to how the player interacts with non-player characters, if I so chose, the player can interact with atomic energy and atomic devices differently through making the right choices and gaining power from these choices, but since the purpose of this prototype is to demonstrate the simplest ways of using the DraGuNa framework and the flexibility of the methodology, I've chosen a different approach for the player's interaction with the atomic energy: allowing the player to make a critical impact halfway through the story based on how the player interacts with atomic energy.

To be specific, one of the characters in the comic, Tony Gardello, will die in the 10th episode of the story. In the original comic book, when the atomic commandos reached Tony, who fought alone to prevent an important scientific invention from being forcefully taken, Tony left his last words and died. This devastated the atomic commandos but led them to work together and avenge Tony by killing the culprits responsible for Tony's death and the stolen invention. Because this event occurs in the middle of the entire story, I've decided to use this as an opportunity for the player to make a significant impact on the story. In the game prototype, if the player has made several right choices and completed the story sequence that deepens the player and Tony's relationship, the player will have the chance to use atomic energy stored in his or her body to give Tony a touch of life. Tony will still be injured, and will not appear again later in the story, for consistency's sake, but certain dialogues will change, when it comes to Tony's death. This serves to strengthen the game's global agency and provides another motivation for the players to be engaged in their interaction with the non-player characters.

Question 2: What drama techniques are used in the game, and how is each technique integrated in the game?

The majority of drama techniques and their integration in the game have been discussed at the beginning of this section, but I will explain two specific drama techniques that are applied dynamically in the game, the use of which is connected to the player's intervention progress: transition and foreshadowing.

Let us first look at how transition and foreshadowing are usually used in a story. As I have explored in Chapter 4, transitions are widely used to signal changes in a character, who most often bring these changes to themselves through obsession or dedication. Similarly, foreshadowing is often used to accompany changes in a character, while increasing suspense and tension in a story. Foreshadowing is usually used before an ill fortune befalls a character, or before a character's own obsessions and wrongdoings bring them into a situation where they would suffer and struggle, but the actual change in a character is implemented through transition. Therefore, two types of satellite stories that portray a character's change lie before us: one where a character becomes better through their dedication and other good qualities, and one where a character suffers through their obsession and other ill qualities. For convenience, I shall call the former transition stories, and the latter foreshadowing stories.

I've built the transition and foreshadowing stories on the basis of the structure of the player character's interaction with NPC's: if the player completes his or her exercise-related homework, he or she will be presented with a transition story, where one of the NPC's would progress toward the NPC's maturity, meaning that the character would become more in-tune with him or herself and adopt a clear idea of his or her purpose; but if, on the other hand, the player does not complete his or her homework, a foreshadowing story will be presented to the player, where the NPC would progress toward a darker nature, begin to reject or despise the player character, or simply lose hope for the future. During game play, these transition and foreshadowing stories will be analyzed and selected by the Narrative Selector that determines the appropriateness of a satellite story in a certain spot in the story, and become an important feedback to the player's actions.

Algorithm ***AddStory*** can be easily customized to select transition and foreshadowing stories. In the Narrative Selector for Adventures of the Atomic Submarine, transition stories and foreshadowing stories are used as the only satellite stories in the game, and a series of restrictions are placed upon the Narrative Selector to choose stories consistent with the flow of the game, discussed as follows:

1. Because a transition or foreshadowing story involves a non-player character revealing a part of himself to the player character, the non-player character involved in the satellite story must be available at the time in the main story where the satellite story occurs.
2. The satellite story must take place at a physical location where the player character is. Because the comic book used in the game has a concise and often abstract depiction of the environment, it is possible to connect two frames that take place in two different places and make the player think they are different perspectives of the same location. For example, a mountain and a plain can both be considered a generic outdoor setting given that nothing in any frame contradicts this presumption. Through analyzing the comic book, any given frame in the game can be categorized as either “inside the submarine” or “outside the submarine”. Therefore, a satellite story needs only satisfy the same category of location as the main story to occur.
3. The pace of the satellite story must match the pace of the main story line at the time the satellite story occurs. In the limited scope of Adventures of the Atomic Submarine, the pace of the story at any given time can be determined by whether a heated encounter with an enemy force is happening, and thus any given frame in the game can be categorized as either “battle” or “relaxed”. In a “relaxed” situation, the player can expect the non-player characters to speak to him or her in a casual way, while in a “battle” state, having the non-player characters speak to the player in a rush makes more sense.
4. It is extremely unlikely that satellite stories can be engaging without referring to what happened previously in either the main story or other satellite stories, or causing any impact in the future story. Therefore, it is in both the game writer and the player’s best interest that the transition and foreshadowing stories are related to the main story or to other transition and foreshadowing stories in some way. However, scripting such stories will pose significant challenges to the game writer, and the challenges grow exponentially as the length of the game increases. Thus, in Adventures of the Atomic Submarine, several satellite stories are linked to each other to create a sense of consistency, as well as to build

up a character's story to create more dramatic tension, whereas satellite story lines have very little connection to each other.

With this infrastructure established, I scripted three to four transition stories for each non-player character, forming five story arcs for each of the five atomic commandos in the story: Bill, Champ, Doc, Tony and Johnny. Each of these transition stories has a priority which increments as the character's story line progresses. In effect, if a player completes three missions in a row, and each time Champ's transition story fits all the prerequisites, the player will experience Champ's transition stories 1, 2 and 3 in order, completing Champ's story arc.

This approach also creates a sense of agency for the player: each time a player receives a satellite story, it is made clear why the player receives the story, so that the player may have a feeling of control over the type of story he or she is getting in the future.

Question 3: How is branching achieved?

Branching in Adventures of the Atomic Submarine is achieved through the Narrative Selector. Two basic rules are applied throughout the design of this Narrative Selector:

Rule 1: The only "choices" that the player is allowed to make in the game are whether or not he or she completes a homework assignment.

Rule 2: Based on a player's homework status, a satellite story that is an appropriate feedback to the player as well as a reasonable occurrence given the progress of the main story should be presented.

While Rule 1 is simple to implement and can be implemented even without any intelligent narrative technology, Rule 2 requires a set of steps to be performed in various points of the story, and thus the Narrative Selector becomes a necessary part of the equation.

Branching is also achieved at a key point in the story, which involves Tony's life or death. This is also achieved by the Narrative Selector, through the accumulation of several homework performance records of the player.

5.5. Adherence Techniques

The application of adherence techniques are primarily attributable to the Narrative Selector in the game: when a player completes a homework assignment, the Narrative Selector chooses a transition story that encourages the player, and when the player fails a homework assignment, the Narrative Selector chooses a foreshadowing story to reflect a negative change in the story. Other hints are, of course, also given to the player. For example, if the player completes a homework assignment, the character who gave the assignment will give an immediate encouragement to the player as a form of social reinforcement, and if the player fails the homework assignment, the character will appear disappointed, or attempt to motivate the player for the next assignment. The game itself will also display a message informing the player that a transition story or a foreshadowing story will be triggered based on the player's performance.

How adherence is maintained through motivation, reinforcement and tailoring is covered by three of the five questions for the game designer as discussed in Chapter 4. Therefore, let us examine the five questions in the game's context one by one.

Question 1: How is the player expected to perform homework in real life?

Because at least for a regular gamer, a computer game is usually played on a daily basis, when integrating homework assignments into Adventures of the Atomic Submarine, an intuitive idea is to present the player with one assignment per game session. Assigning more assignments and prolonging a game session risks making the game play a burden to the player. A question inevitably arises, as I've discussed earlier: should the player perform the homework during their game play, or should the player perform the homework between game sessions?

There have been many examples of games having the player perform certain tasks during game play to improve their physical activity, although these games are normally not designed under the principle of a sophisticated behavior change model such as the TTM, and studies have shown conflicting results of whether this type of active video games can promote long-term behavior change (Baranowski et al. 2012, Graves et al. 2010, Maloney et al. 2012, Owens et al. 2011).

Although the conflict of results can be attributable to many reasons, I've decided to avoid potential pitfalls by using the alternative approach: having the player perform homework between game sessions. In Adventures of the Atomic Submarine, a homework assignment is given at the end of each game session. Due to the nature of these assignments, the player may spend somewhere between five minutes and one hour to complete each assignment. In other word, the player will not need more than a day to complete a homework assignment, if he or she indeed takes the effort to do it. Therefore, the game is designed so that the player can play at most one game session per day, so that they will be given the time to do the homework, reducing the incentive to lie about completing a homework assignment just to advance the game, while giving the player more time to digest the information they have acquired from the previous session.

Question 2: In what way is the homework assigned?

For the behavior change intervention to make sense in the game, a basic story of why the player needs to perform the exercise-related homework assignments must be weaved into the main story.

In Adventures of the Atomic Submarine, the player takes on the role of a World War II hero who has lost his or her memory when saving Bill Tyler from the atomic bomb at Hiroshima. The player character has lost his or her memory and has become physically weak, which provides a reason for the character to exercise, so as to regain physical strength and lost memories. This also serves as the reason why the player must perform similar tasks as they impersonate the character. For the background story to make sense, the concept of regaining strength and memory must be introduced to the player before the first homework is assigned. In the game, this is done in the first session, immediately following the description of the atomic submarine's construction, when the player character slowly wakes up in the White House, at which point the President of the United States asks the player character's name and gender, and proceeds to explain his or her role in the plot surrounding the atomic submarine. The President will also inform the player that scientists in the White House has designed a set of missions for the player character to slowly regain his or her strength, and hopefully in the process he or she might regain his or her memories.

As the player character travels the world on the atomic submarine and ventures into the depths of the Earth or the backyard of enemy territory, an important question is how each homework assignment is assigned to the player. A simple solution that makes sense in the story is to have the player contact the White House or an authority each time for a new mission, but this approach can quickly become repetitive in over 20 sessions of game play. In the Adventures of the Atomic Submarine, I've decided to take a different approach, where each assignment is presented to the player by a character currently active in the story. It needs explaining that the atomic commandos often split up to perform different parts of a teamwork, and therefore at a specific moment some characters may not be actively engaged with the story. Since the player plays an extra role on the team which does not exist in the original comic book, the game progresses in a way that assumes the player character follows the NPCs that are currently active in the story. It is only reasonable that, without the introduction of an extra communication channel, only the characters accompanying the player character can assign a mission. Therefore, in the game prototype, each session has a certain character assign the mission, but because the actual homework assignment may be different for each player in each session, depending on the player's stage of change and their previously performed homework assignments, I created a placeholder in each session where the mission's content can be inserted. In summary, this is essentially a template for giving homework assignments.

Question 3: How is the player motivated to perform homework?

In this work, I decided to use the persuasion techniques proposed by Roberts: reciprocation, consistency, social proof, liking, authority, and scarcity (Roberts et al. 2009), since this is a concept already explored in the intelligent narrative technologies research. To understand how these techniques can be implemented in the game, we must look at the way a player can receive a motivational message. In Adventures of the Atomic Submarine, the player receives information through either the narrator of the comic book or through conversations among characters. In drama, information conveyed through a character's words and actions is usually preferred to a narrator's intervention. Therefore, in the game, I've decided to arrange certain scenarios where a non-player

character, when perceiving the player's unwillingness to complete a homework assignment, may argue with a persuasion technique to try to get the player to continue completing homework. A non-player character may perceive the player's unwillingness to complete homework at two places in the homework assignment sequence: the time when the player rejects a new homework, and the time when the player fails to complete a previous homework assignment.

When the player rejects a homework assignment, the character giving the homework has an opportunity to address the rejection. Without delving into the reason why the player rejects the homework, which will require accurate processing of the player's input to an unrealistic level, the game adopts a system that uses one of five persuasion techniques to convince the player to accept the homework, and the game delivers the message through one of the non-player characters. Figure 5.2 is the sequence which the game follows to deliver such a message:

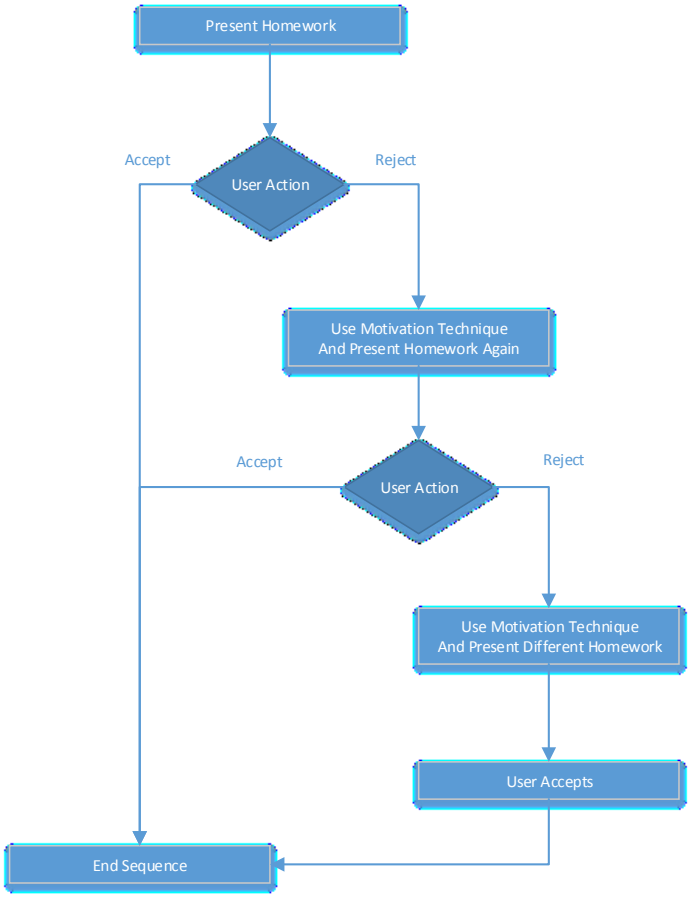

Figure 5.2. Sequence for delivering motivation technique

When the game decides to use a motivation technique, it chooses from five available techniques: consistency, social proof, liking, authority and scarcity defined in Section 4.2.2. I selected these five techniques from Roberts' collection (Roberts et al. 2009) because techniques based on reciprocation will require the non-player character to have done something for the player character, and under the design of this game, having non-player characters do favors for the player character, and to do so repeatedly due to the longitudinal nature of the game, will pose a significant challenge for the dramatic flow of the story. Therefore I've chosen not to include reciprocation as a motivation technique. Each non-player character that ever gives the player a homework assignment (Bill, Tony, David, Edwin, and Johnny) has five motivation statements, each statement corresponding to one of the five motivation techniques. The game maintains a score for each motivation technique for any player. At the beginning of the game, these scores are assigned initial values. As the game progresses, when a motivation technique is needed, the technique with the highest score will be picked, and the corresponding motivation statement written for the character giving the homework assignment will be presented. However, if the player still rejects the homework or fails to complete the homework after viewing the motivation statement, the motivation technique being used will have a decreased score, so that the player will not receive repeated attempts of using the same motivation technique. A failed motivation technique will not be used again until all other motivation techniques have also failed at least once.

In addition to adjusting motivation scores, when a player fails to complete a homework assignment, it is also an opportunity to motivate the player to complete future homework. This is done by having the character who is inquiring about the player's homework progress (usually the same character who assigned the homework) encourage the player to do better and explain his own understanding of the failed homework assignment. For example, if the player, in the fifth game session, receives the homework assignment of "pay attention to movies, comics, games, or TV shows, or reflect on the movies, comics, games, and TV shows you have watched before, where a character has the habit of exercising. Think thoroughly about the qualities these characters have", and if the player fails to complete it, Bill Tyler's response would be: "If this could inspire you, I want to mention Batman. Have you read the comics? I really like his character. He works out to get strong. There

are some criticisms on the tone of the comic book, but I'm sure he will become a popular hero in America." (Batman was just introduced at the time the story occurs, so this is an in-character response that also breaks the fourth wall.) Bill would then continue to encourage the player by saying "Maybe over time you'll get used to the missions. Sometimes you just got to forget about all the things that are bothering you and start doing it. You'll do better next time all right!" These responses are hard coded and are meant to encourage the player to work harder in the future.

Question 4: How is the player reinforced when they complete homework?

Earlier, I mentioned the use of transition and foreshadowing stories in the game to improve the player's engagement. Besides their dramatic value, these transition and foreshadowing stories are also a means of reinforcement. In Adventures of the Atomic Submarine, when a player completes a mission, the game rewards the player with a transition story, where one of the non-player characters reveals something in his heart and gets closer to the player character; when a player fails to complete a mission, the game presents the player with a foreshadowing story, where a non-player character reveals his worries for the future, or complains about the player character's lack of action, and grows apart from the player character.

In Section 4.2.3 and with Figure 4.4, I explained the feedback loop encouraged by the DraGuNa framework, where the completion of a character arc leads to a more meaningful, more engaging reward. Fitting into Figure 4.4, in Adventures of the Atomic Submarine, encouraged player behavior will lead to a satellite story, and once an NPC's character arc is completed, a more valuable reward is given to the player, and in this case, this final reward can as well be a satellite story. This decision is made to maintain consistency of style throughout the game and to stay within the narrative-heavy emphasis of this work.

The more valuable rewards must be something of more significance in the story than the existing satellite stories. A few types of information that can be conveyed, for example, include events that can change the course of the story, events that are occurring in parallel to the current story, and events that happened in the past. For events to change the course of the story, the changes must

be either scripted into the story or calculated based on pre-existing events, both of which go beyond the scope of this work. For events happening in parallel to the current story to have any significance in the player's eyes, these events must also have some impact on the current story, and this will require the development of additional story lines, which also pushes the boundaries of this work. Events that happened in the past are the most straight-forward to implement. In this work specifically, because the player character has lost his or her memories, what happened in his or her past is an important mystery that causes continued suspense in the story, and therefore I've chosen to use the revelation of the player character's past as a valuable form of reward. The feedback loop of Adventures of the Atomic Submarine eventually looks like what is illustrated in Figure 5.3.

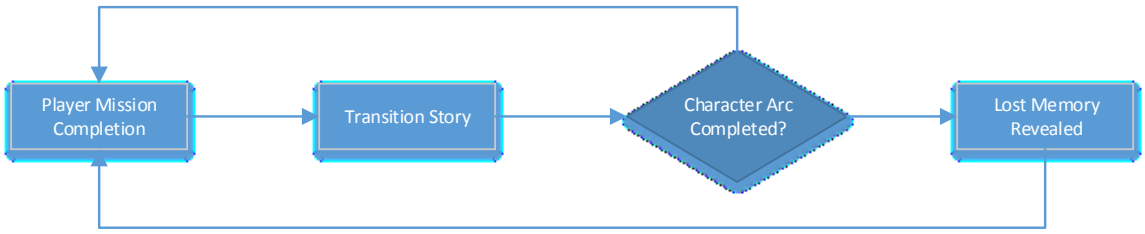

Figure 5.3. Feedback loop of Adventures of the Atomic Submarine

Four lost memory stories were scripted, describing the player character's participation in World War II as a veteran, the player character's fall on the battlefield, the first meeting with Dr. Oppenheimer after the player character's miraculous resurrection, and finally, Oppenheimer's explanation of the technology that binds atomic energy in the player character and the use of such power. Only four of these additional stories were created because even if the player completes every mission, within the length of the game, only four character's story arcs can be completed, thus only four memory stories are needed.

Integrating the memory stories in Algorithm AddStory is also not difficult. For memory stories to be properly triggered at the end of each character's story arc, all memory stories must possess higher priority ratings than the rest of the satellite stories, and at the end of each character's story arc, a flag is set so that the requirement for triggering a memory story is met. After each memory story,

the flag is set back to false, so that memory stories become dormant again. Among the four memory stories, priority still increases by the order in which the stories are meant to be triggered.

Question 5: How is the homework tailored to the player?

The last part of player adherence is achieved by homework tailoring. The missions in Adventures of the Atomic Submarine are real-life homework assignments that were designed to help the player advance in their exercise stage of change, and these missions were designed to cover ten processes of change as described in Chapter 3 and Appendix A. Because individuals in any given stage of change may only benefit from certain processes of change, it is necessary to tailor the missions to the player's stage of change. In this work, mission tailoring is achieved by assessing the player's stage of change in the beginning, and assigning only missions that are suitable for the player's stage of change. When assigning missions, the game alternates between different processes of change, and assigns easier missions in the beginning, and later assigns missions that are progressively more difficult. When a player rejects a mission twice, following the sequence in Figure 5.2, the game also assigns a mission in an alternative process of change, and the rejected mission is stored for future use.

As argued in Chapter 4, ideally, tailoring can be done continuously during game play. It is reasonable to reassess the player's Stage of Change sporadically between sessions of game play and, upon detecting a change in the player's behavior, adjust the homework assignment scheme. Given the short scope of this work, with Adventures of the Atomic Submarine containing only 21 game sessions, which can be completed within 21 days, reassessment and continuous tailoring are not implemented. However, these features may be considered in the design of health games that operate in a larger time scope.

5.6. System Architecture

When it comes to game design, three popular approaches exist: 1) a single-player architecture, where everything is stored and computed on the player's computer, although communications to a server can be established to transfer data, 2) a web-based architecture, where everything is stored

on a server and downloaded to the player's computer at run-time, and 3) a hybrid architecture used by multi-player games, where resources that take up huge amounts of space and may take a long time to download are installed on the player's computer, while algorithms that process the player's input and gives the player feedback are stored on a server. For the design of Adventures of the Atomic Submarine, a few factors must be considered.

First, because the game will be used in a study which aims to examine the player's behavior during and after game play, it is of utmost importance that the player's essential actions in the game be recorded and securely stored where the researcher has access to. It is possible to use approach 1) as mentioned above, using an Internet connection to transfer the user's behavior data, or alternatively requiring no Internet connection and asking the user to email a copy of their locally stored behavior data to the researcher, or bring the copy to the researcher at the end of the study. However, asking the user to submit the data adds unnecessary burdens on the user and may be a cause for the user's not returning to the researcher when the study completes. Therefore, approach 1) with an Internet data transfer, as well as approaches 2) and 3) are preferred. In any case, a server program is required.

The second concern for the game design is to minimize the Internet traffic. Because the primary testing ground for the game is an academic study, there is no predicting what type of Internet a user may have. In order to recruit a diverse background of participants, I also do not want to lay too many restrictions on the user's computer and Internet connection. Therefore, the best thing to do is to ensure as little content is passed between the user and the server. Like in many commercial games, a good approach to take is to install all the game's required resources, including all the images, animation, sound files, etc. on the user's computer. Therefore, a pure web-based approach can be rejected.

Between a single-player architecture and a hybrid server-client approach, I've decided to choose the latter. This is simply a choice of convenience: since the server needs to store data to and retrieve data from a database, both of which may be necessary for the core algorithm and other related functions, it is more convenient and organized to deploy the narrative selector and related

functions on the server. Testing database-related functions also becomes easier as compared to splitting the functions on two computers. The resulting architecture is illustrated in Figure 5.4, as follows.

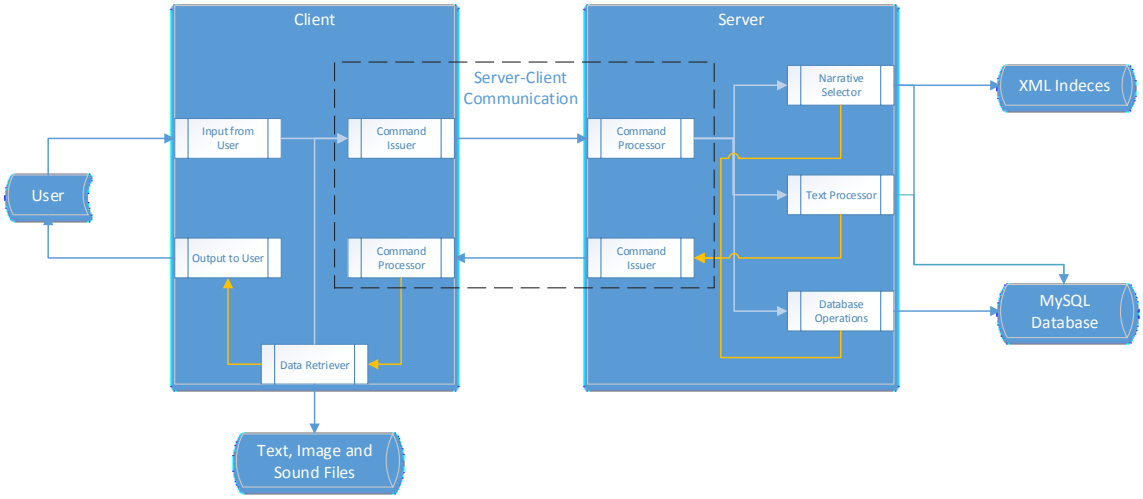

Figure 5.4. System architecture

5.6.1. Client

The game client is developed using the Ren'Py game engine, commonly used to produce visual novels. Through a few simple hacks, the game engine is used to support an interactive comic book platform. With this approach, each game session is divided into three parts on the client side: game start, game body, and game end. During game start, the client initializes game configurations and displays the main game menu, as shown in Figure 5.1. Once the user clicks on "Start Game", the game body begins. During game end, the client sends a "game end" message to the server, and closes the client. During game body, as illustrated by Figure 5.2., the client has four primary functions: processing user input, retrieving resources, communicating user commands and script commands with the server, and displaying the results to the user.

Processing User Input

There are three types of user input: click, button click, and text input. Throughout the game, the majority of game play involves the player clicking on the screen to read the next text bubble, or

move to the next frame, or to the next page of comic book. Whenever the user clicks on the screen in this state, it is called a “click”, a message will be sent to the server to keep a log, and the next line in the current story file will be processed. Occasionally, a menu will pop up, asking the player a question related to their mission: whether the player has completed the previous mission, or whether the player is ready to accept the next mission. These are simple yes/no answers, and once the player clicks on a button, the choice is made. This is called a “button click”. When this occurs, in addition to sending a message to the server, the program also requests the server to update certain variables based on the player’s choice, and update the current story in case new narrative elements can be included, or used to replace existing ones. Yet other times, a player’s text input is required. This is triggered when the player’s response to a previous mission is needed. This is called a “text input”. When a text input is completed, meaning the player hits the “enter” key, a request for log update along with a variable update associated with the text box are both sent to the server.

Retrieving Resources

The Data Retriever module in the client handles all processes related to text, image and sound files. The text files contain scripts that determine the content and sometimes server functions throughout a game session. With the only exception of a menu, the text files are processed one line at a time, each line being an independent command that the client must process. The full list of commands that can appear in a text file is explained here.

Load Image: Each text file begins with this command, requiring the client to load a particular image and display to the player. This command is a JPEG file name followed by five numbers, determining the image file to be loaded, the anchor coordinates (the basis from which the other coordinates are derived), the coordinates that is currently displayed, and the scale of zoom onto the image. This command can only appear at the beginning of a script file. The format of a “load image” command is therefore:

<FILENAME> <ANCHOR X> <ANCHOR Y> <X> <Y> <ZOOM>

Text Bubble: The most common command in a text file is to display content as a text bubble. This command consists of a string of text followed by four numbers, indicating the coordinates where the text bubble begins, and the size of the textbox. This is just a transparent square area that displays text, and must be combined with what is shown in the image to create a proper text bubble. The format of a text bubble command is:

<TEXT> <X> <Y> <WIDTH> <HEIGHT>

Figure 5.5. Narrator text

Narrator Text: Sometimes, a chunk of text needs to be displayed as if uttered by a narrator instead of a character in the frame. In the original comic book, these narrator texts are displayed above a frame. In Ren'Py, following the conventions of visual novels, text can be easily displayed at the bottom of the screen, as in Figure 5.5. In the scripts, this is simply a line of text not followed by any number. The narrator text command is simply:

<TEXT>

Frame Transition: Frame transition is the command that moves the screen from one frame to the next, using a linear camera movement that lasts 0.5 seconds. The command begins with the keyword "FRAME" and continues with three numbers, determining the coordinate on the image that

the screen is moving to, and the new scale of zoom onto the image. The frame transition command is:

FRAME <X> <Y> <ZOOM>

Play Music: As its name suggests, this command controls the background music of the game. Two sound tracks have been developed for the game: “It hit the fan” is a slower track used for the parts of the story involving the daily life of the atomic commandos; and “Ruskies and outer space Charlies” is an intense track used when a battle occurs. When the music needs to change, the command “PLAYMUSIC” will be scripted, followed by a unique code designated for each of the music files. The command for playing music is:

PLAYMUSIC <MUSIC CODE>

Play Sound Effect: Through the majority of the game, only one sound effect is frequently played: the sound of clicking. When the player clicks on the screen, or presses space or enter to advance the game, a crisp sound is played. However, to make the feedback obvious for the player’s mission completion and failure, another two sound effects are played when the player claims that a previous mission has been completed or failed, and when a satellite story is completed. Because of the infrequent change of the sound effect, instead of implementing a command to play a sound effect, I implemented a function called “SETSOUND”, which, followed by the sound effect’s file name, will set the sound file to be played on the next click. When a different sound effect needs to be played, this command is used, and after the scripts where the sound effect is necessary, this command is used again to set the sound effect back to the one for clicking. The command for setting sound effect is:

SETSOUND <SOUND FILE NAME>

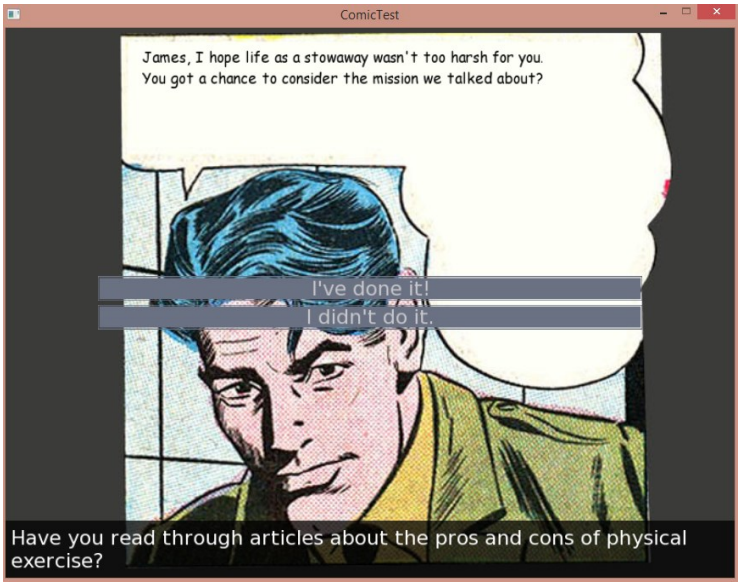

Figure 5.6. Menu

Display a Menu: When the player's mission progress is being checked, or when a new mission is assigned, the player needs to make a choice, and this is when a menu comes into play. A menu includes a narrator text, a few options and, optionally, narrator text that will be displayed after each player choice, and possibly updating a variable to reflect the player's choice. Because of the way Ren'Py handles menu items, a menu cannot contain an arbitrary number of options. In the implementation of Adventures of the Atomic Submarine, up to five options are supported, which is well beyond the Yes/No choices the player is always offered. Given that a menu has K options, the format of the menu command is as follows:

MENU <NARRATOR TEXT> K

(<OPTION> <RESULTING NARRATOR TEXT> <VARIABLE> <NEW VALUE>)^{K}

User Input: Once per game session, except for the first, the player will be asked about his or her mission progress. Whether the player has completed the mission or not, a user input is required to record either the player's findings regarding the mission (if the mission is completed), or the player's reasons for not completing the mission (if the mission is failed). This is implemented as a text field

at the bottom of the screen accompanied by a text prompt, as shown in Figure 5.7. The command for user input is as follows:

INPUT <TEXT>

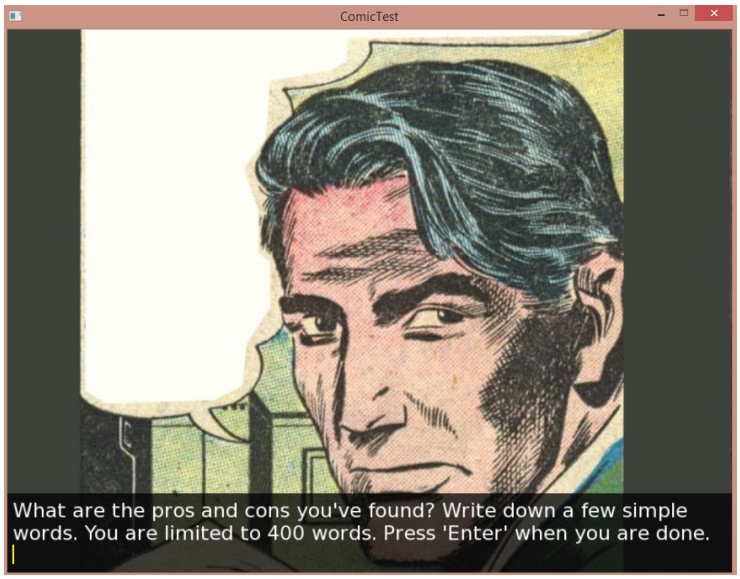

Figure 5.7. User Input

Set a Variable: Sometimes, as in a piece of satellite story, the story's state needs to be changed, so that changes can be made to later story pieces. In such a situation, a variable needs to be modified on the server. A command can be used in the script to trigger a variable change, in the following format:

SET <VARIABLE> <VALUE>

Call a Function: When a mission is completed or failed, or when a new mission is about to be assigned, more than a variable needs to be modified on the server, and a more advanced logic must be used. In such a situation, a function needs to be called, and this can be done in a script by the following command. Note that this implementation is limited to a function with no parameters.

FUNC <FUNCTION NAME>

End of File: The end of each script file is marked by a special syntax. This is to avoid the rare occasion of a misplaced empty line between valid lines of scripts. The command is simply:

END

End of Game: Upon the end of a game session, the client will display the title image again and display a message reminding the player to complete the current mission and log back in the next day. This is triggered by the following command in a script file:

GAMEOVER

```
1  ind-bill.jpg    0   0   -700    -100    1.2
2  FUNC    preparemotivation()
3  $hwmotivate 220 10  330 100
4  FRAME   -700    -850    1.2
5  So will you reconsider it?  40  10  150 100
6  Your mission: $hwassign 40  10  150 100
7  MENU        2
8  Accept  You have accepted the mission!  curhw   ongoing
9  Reject  You have rejected the mission.  curhw   rejected
10 END
```

Figure 5.8. A typical script file

Figure 5.8. demonstrates a typical script file. Line 1 loads the image file named “ind-bill.jpg” with (0,0) as the anchor and (-700,-100) as the location of the top-left corner of the screen, and 1.2 as the zoom size. Line 2 calls the function named “preparemotivation()”. Line 3 then displays a message at (220,10) with a width of 330 and height of 100. The “$hwmotivate” part of this line will be replaced by a string value from the server at run-time. Line 4 moves the camera to location (-700,-850). Lines 5 and 6 each displays a text bubble, both at the same location (40,10) with width 150 and height 100. Lines 7 through 9 form a menu of two items, the first item reading “Accept”, and the second reading “Reject”. If the player chooses “Accept”, a narrator text “You have accepted the mission” will be displayed, and the variable “curhw” will be set to “ongoing”; if the player chooses “Reject”, a narrator text “You have rejected the mission” will be displayed, and the variable “curhw” will be set to “rejected”. Finally, Line 10 indicates the end of this script file, and commands the client to load the next script file in line.

Communicating with Server

Each player action and script item triggers a communication from the client to the server. In the client's communication module, a total of nine commands are used to send messages to the server, which also expect a response from the server so as to inform the client to perform further actions. Following are the Python functions used in this communication:

senduserid(userid): This command is used to pass the player's user ID to the server for the purpose of verification. This command is only used at the beginning of a game session, as soon as the player has entered his or her ID.

sendlog(logstring): This is the command that is used most often throughout the game. Each time a new text bubble or narrator text is displayed, or a new menu or user input is triggered, or the player has pressed a button on a menu, this command is triggered to send a log entry to the server, which is in turn recorded in the database. The log typically contains the text that is being displayed or clicked upon, but sometimes it is a descriptive message, such as "game start" or "game end".

edittext(sentence): When a text is about to be displayed, part of that text string may be a placeholder, such as "$hwmotivation" as shown in Figure 5.8. These placeholders, at run-time, needs to be replaced by meaningful words or sentences. Therefore, before each text is displayed, this command is used to pass the entire sentence to the server, where these placeholders are replaced by run-time values, and the new sentence is passed back to the client and displayed to the player.

firstfile(): This command is used at the beginning of a game session, immediately after senduserid(userid), to request the name of the first script file of the current game session.

nextfile(): Similar to firstfile(), except this command is called every time the end of a file is reached and the name of the next script file is requested from the server. More details on the file request system will be explained in 6.6.2.

updatevars(key, val): This function is used to set the value of a variable on the server. This can be triggered through two means: when the player chooses a menu item, the associated variable is set

through this function; or somewhere in the script, when the SET command is used, this function is used to set the target variable's value on the server.

updatestory(): This function is used to issue a command to the server so that the current game session's story can be re-arranged. Re-arranging the story usually happens on the server side, but when a player chooses whether he or she has completed the previous mission, the command is used on the client side so that an immediate response can be inserted to give the player feedback.

perform(funcname): This function is used to request the function with the name "funcname" to be called on the server. This function is triggered only from the script directly, using the syntax "FUNC".

endgame(): This function is used when the game session ends, where the server registers the end of the session and the client shuts down.

Outputting to User

Displaying content to the player is accomplished using Ren'Py's built-in functions. Only a handful of functions are necessary in Adventures of the Atomic Submarine: showing a background image using the "show" syntax, displaying a text bubble using "show expression", displaying a narrator text using double quotes, showing a menu using "menu", retrieving user input through "renpy.input()", and playing music and sound effects using the "queue music" and "play sound" operations. A full list of Ren'Py functions can be found at the game engine's official website: http://www.renpy.org/doc/html/

5.6.2. Server

The server contains a core class: Storyarc, which controls the flow of the story of each game session. When a player's user ID is verified, an instance of Storyarc will initiate the player's current game session, by forming a sequence of script files to be used one after another in this session. The sequence of script files is constructed based on the player's story index on that particular day in XML format, which will be explain in detail in Section 5.6.4. Immediately after the story sequence is formed, the server also retrieves data from the database to construct a full list of all missions and

all motivation techniques, so that algorithms can act upon these lists to pick the appropriate mission and motivate the player to complete the mission at a later time.

As illustrated in Figure 5.4, once the initial configurations are complete, the primary functions of the server include communicating with the client, communicating with the database, processing text messages, and conducting narrative selection.

Communicating with the Client

The server responds to every request from the client with a function in the Storyarc class. The full list of functions, except for one which is responsible for processing text bubbles and narrator texts, is explained as follows.

firstfile(): This function responds to the client command of firstfile(). This function retrieves the name of the first file in the story sequence.

nextfile(): This function responds to the client command of nextfile(). This function retrieves the name of the next file in the story sequence and moves the pointer to the next file in the story sequence.

updatevars(var, key): This function responds to the client command of updatevars(var, key). It may also be called by other internal functions in Storyarc. When called, this function checks if the variable named “var” exists in the database: if it exists, the variable’s value is updated to “key”; if it does not exist, a new variable named “var” is inserted with the value of “key”.

updatestory(): This function responds to the client command of updatestory(). Based on recently updated variables, this function looks for satellite stories that can be added to the current game session by using a narrative selection algorithm. The function is also responsible for replacing a chunk of story, which is an immediate feedback to the player’s mission progress, based on whether the player has completed the mission or not.

Other functions can be called through the client’s “FUNC” command. This is implemented on the server with Python’s exec() operation, which maps a string to a function. These functions include

setting the player's new mission assignment, choosing which motivation technique to use for the current game session, and changing the player's game state after the player completes or fails a mission.

Communicating with the Database

All database-related operations are conducted through the Dbclass class, an instance of which is declared inside of the Storyarc class. The Dbclass contains the following functions:

checkuserid(userid): This function checks whether the specified user ID exists in the database, and if it does, whether the player has completed a game session on the same day, and whether the player has completed the entire game, in which cases the player will not be allowed to log in again.

setuserid(userid): This function is used after the checkuserid(userid) function, when the player is determined to be valid, and a game session can proceed. The player's user ID is registered within this instance of Dbclass, and the player's game session number will also be retrieved and updated.

writeGlobalVars(globalvars): This database operation is performed at the end of each game session, to write all variables into the database, which on the server are stored inside a dictionary named globalvars, in the Storyarc class. When the function is called, it also adds the interaction day after the variable's value in the database entry, so that a complete history of the player's daily variable changes can be tracked.

readGlobalVars(): This function is performed at the beginning of each game session, to load all database variables of the current interaction day into the globalvars dictionary.

writeMotivations(motivation): Like writeGlobalVars(globalvars), this function is also called at the end of each session, except to record the player's motivation technique rankings instead of other variables. This function is called separately because the motivation rankings are stored in a separate table as compared to the global variables.

readMotivations(): This function is called at the beginning of each game session, to load a player's motivation rankings. Section 5.6.3 will offer more details.

setLog(logstring): This function is called in response to the client's sendlog(logstring) command. It records a log entry into the database. Section 5.6.3 will explain the log table in detail.

Processing Text Messages

Before a text can be displayed to the player from the client, either as a text bubble or as a narrator text, the text must be processed to replace placeholders with run-time content. This is done by detecting certain keywords in an incoming text and mapping each keyword to a function which returns a new value specific to the player. The most important placeholders are the player's name as used in the game and the player's gender. Several keywords are used, when the player character is referred to in third person perspective, so that the character's gender can be reflected in the appropriate form, including subject, object, possessive, possessive pronoun, and a few others such as man/woman, guy/gal, boy/girl, and Sir/Ma'am. Besides these, a few more keywords need additional explanations.

$connphrase: This placeholder appears whenever a satellite story is about to happen. A satellite story is inserted into the game based on the player's mission progress, and therefore it is impossible to tell which satellite story will be inserted into which game session beforehand. To create the sense of a coherent story, a connection phrase placeholder is used to refer to the current situation of the story. For example, in the following sentence, the $connphrase is a placeholder: "$connphrase Tony stopped by with his constant smile even in the direst situation." During the game session, the $connphrase can be replaced by "Just as the commandos were in the midst of gaining balance from a mysterious metal fish attack," in game session 10, or by "While the atomic commandos made plans for a surprise attack," in game session 11. These replacements are defined with the "SET" function in the respective script file.

$hwassign, $hwreport and $hwmotivate: These three placeholders are essential for assigning a mission and checking the player's mission completion. $hwassign is used to announce the next mission assignment to the player inside of a text bubble. $hwreport is replaced at run-time by a sentence inquiring about the player's homework progress. $hwmotivate is used when the player

rejects a mission, and the non-player character who assigns the mission tries to motivate the player to accept the challenge. As explained earlier, five motivation techniques are used in this game, and the motivation technique with the highest ranking will be picked. Each non-player character has a unique way of using each of the five motivation techniques, and the $hwmotivate keyword simply triggers a function to retrieve the appropriate motivational response from the mission-issuing character.

$hwsuccess and $hwbenefitsuccess: When a player completes a mission, the game prompts the player to input his or her findings for the mission. This prompt is crafted specifically for each mission, and since each mission can be given to the player at any given session, the prompt needs to be dynamically retrieved at run-time. This is done using the $hwsuccess placeholder. Once the player finishes typing in their answer, the non-player character who has issued the mission shall give the player some feedback, which is also mission-specific. This is done using the $hwbenefitsuccess keyword and replaced at run-time.

$hwfailure and $hwbenefitfailure: Similarly, when a player fails a mission, the game also prompts the player to input the reasons why he or she could not complete the mission, and the non-player character who has issued the mission will also give the player some feedback regarding the mission. These are achieved through the $hwfailure and $hwbenefitfailure keywords.

Narrative Selection

Narrative selection is the process of picking a satellite story that advances a certain non-player character's story arc, where the player gets to know the character better or where the character's past is revealed. Alternatively, a satellite story can also reveal part of the player character's past, which is lost to the player character's amnesia, as already explained in detail earlier.

5.6.3. Database

The server communicates to a MySQL 5 database. There are five tables in the database: users, globalvars, motivation, logs, and usedfiles. Each table and its fields are explained in this section.

users: This table contains all the basic information related to a particular player, including the player's user ID (user_id, primary key), the date of the player's first game session (start_date), the number of days that have passed since the player's first session (study_day), the study condition that the player has been assigned to (study_condition), the player's email address (email), the unique number that identifies the previous game session, from 0 to 21 (interaction_day), and the date of the player's most recent game session (last_login).

globalvars: This table records the full history of the variables associated with each player's account, including whether the player completed or failed a particular mission, and the player's stage of change which is used to determine the types of missions he or she will receive, based on the Trans-Theoretical Model. The data base contains the player's user ID (user_id, primary key), the study day on which the variable is set (study_day, primary key), variable name (varkey, primary key), and the variable's value (varvalue). Because user_id, study_day and varvalue are together this table's primary keys, the table maintains a record of each and every change to a player's every variable.

motivation: This table records the full history of the motivation technique rankings associated with each player's account. Motivation techniques are used to encourage a player to accept a mission when the player is leaning toward rejecting it. There are five motivation techniques that can be used in Adventures of the Atomic Submarine, as discussed earlier. Each motivation technique has a score, and the technique with the highest score will be used in the immediate next session. Therefore, this table maintains the player's user ID (user_id, primary key), the study day on which the motivation rankings are set (study_day, primary key), the motivation technique's name (motivation, primary key), and the technique's score on the specific study day (rating).

logs: This table records the entire history of each player's interactions with the game. The table contains three fields, the player's user ID (user_id, primary key), a piece of log (log_entry, primary key), and a timestamp when this log entry is made (log_time). In the log_entry field, a log is usually the text bubble or narrator text displayed to the player, or the menu option that the player has chosen, or the player's manual input, but it can also contain internal operations on the server that are triggered by scripts, such as "game start", "game end", "enter file", and "set variable".

usedfiles: This table records the full list of script files that have been used for each player. The table contains the following fields: the player's user ID (user_id, primary key), a script file's name (filename, primary key), and the study day on which the script file is used (day_used). In a previous development cycle, this table was used to determine the script files that should be used in each new session, but in the final design, the script files are indexed by XML indices, which will be explained in the next section, and thus the usedfiles table has become obsolete.

5.6.4. XML

One important function of the server is to determine and organize the story that a player receives in each game session. In practice, the server uses a series of XML files to index the script files that can be used for each game session. During game play, these XML indices are searched through to form a story sequence. In addition, XML files are also used to organize missions and motivation techniques. The details of each function are explained as follows.

Story Index

To demonstrate how the server uses XML to index story chunks, let's look at a sample XML file, which is used to guide the second day of game play, as shown in Figure 5.9.

```
<data>
    <file name="hw1-check">
    </file>
    <file name="hw1-success">
        <req prehw="success"/>
    </file>
    <file name="2-2">
    </file>
    <file name="2-3">
    </file>
    <file name="2-4">
    </file>
    <file name="2-5">
        <change loc="outside" state="mission" tony="available" doc="available" bill="available" champ="available" jonnie="unavailable"/>
        <follow>transition</follow>
        <follow>foreshadow</follow>
    </file>
    <file name="tutorial2">
    </file>
    <file name="2-6">
    </file>
    <file name="2-7">
    </file>
    <file name="2-8">
    </file>
    <file name="2-9">
    </file>
    <file name="hw2-assign">
        <follow>homework</follow>
    </file>
    <file name="2-10">
    </file>
    <file name="endofday">
    </file>
</data>
```

Figure 5.9. XML story index for game session 2

The sample file contains almost every syntax used in the XML indices. On the highest level, <data></data> wraps the entire XML tree, within which are a series of <file/> tags, each representing a script file that exists on the client side. There are four tags that can exist inside of a file representation: <follow/>, <req/>, <type/> and <change/>. The <follow/> tag defines the types of file that can follow the current file. This becomes useful during a game session, when the narrative selector attempts to add a transition story or a foreshadowing story to the story sequence, or when the homework mechanic needs to pick a mission and adds it at the end of the session. The <req/> tag defines the conditions that must be met for a file to appear in the game sequence. For example, in the sample XML, the "hw1-success" file can only exist in the game session if the previous mission has been successfully completed, i.e. when the variable "prehw" equals "success". At run-time, the server checks for these <req/> tags constantly, and once one is detected, the server will check the variables that appear in the tag to validate the state. At the moment a variable does not match what is required in the <req/> tag, another XML database, "replace.xml" will be searched through to find a replacement file. The <type/> tag, corresponding to the <req/> tag, defines the type of a story file, including "homework", "transition", and "foreshadowing". An example will be explained in the next paragraph. Finally, the <change/> tag appears where variables need to be modified. This works in the same way as the "SET" command on the client side, except the <change/> tag also triggers a call to the narrative selector, so that a change in the story sequence can be potentially made.

An additional set of story file representations exist in a separate XML file: add.xml, which contains the XML index of the entire pool of transition and foreshadowing story files. Figure 5.10 shows a portion of the file, which contains Tony's transition story files.

```
<file name="tony-transition-1">
    <req prehw="success" state="mission" tony="available" tony-transition="4"/>
    <type cat="transition" target="tony-transition"></type>
</file>
<file name="tony-transition-2">
    <req prehw="success" state="rest" tony="available" tony-transition="5"/>
    <type cat="transition" target="tony-transition"></type>
</file>
<file name="tony-transition-2-mission">
    <req prehw="success" state="mission" tony="available" tony-transition="5"/>
    <type cat="transition" target="tony-transition"></type>
</file>
<file name="tony-transition-3">
    <req prehw="success" state="rest" tony="available" tony-transition="6"/>
    <type cat="transition" target="tony-transition"></type>
</file>
<file name="tony-transition-3-mission">
    <req prehw="success" state="mission" tony="available" tony-transition="6"/>
    <type cat="transition" target="tony-transition"></type>
</file>
```

Figure 5.10. The XML representation of Tony's transition story files.

Tony has three transition stories, but there are five file representations because certain stories can happen under multiple sets of restrictions as defined in the <req/> tags. For instance, "tony-transition-2" and "tony-transition-2-mission" point to two slightly different files depicting the exact same story, due to them sharing certain elements: In the <req/> tag, each of these file representations have "tony-transition" assigned to "5", meaning they both need Tony's transition storyline to progress to a certain level: 5; in the <type/> tag, each of these file representations has "cat" assigned to "transition", meaning their category is "transition", and each has "target" assigned to "tony-transition", meaning they target the same story arc (transition) of the same character (Tony). The only element that differs between the two representations is the "state" attribute in the <req/> tag: one has "rest", meaning the state of the game needs to be at "rest" for the event to occur, and the other one has "mission", meaning the state of the game needs to be at "mission" for the event to occur. This is one of the significant factors that determine whether a satellite story can occur: whether the Atomic Commandos are on a mission, or in a more relaxed state. Besides "state", the attribute "loc" also determines whether a story file can be inserted into the game sequence, indicating the physical location where the story is happening. A particular character's availability, meaning whether the character is where the player character is (for instance, the attribute "tony" in the sample file), and the previous mission's completion (the "prehw" attribute) can also determine whether a story file is eligible to be inserted into the story.

A few special story indices exist: the mission story indices. These are different from the indices that contain information about missions, as will be explained below. Mission story indices are indices of story files that are related to the assignment or reporting of a mission. These indices are partially hardcoded in story indices, and partially stored in “replace.xml” and “add.xml”. A sample mission story index is shown in Figure 5.11. It is similar to a regular story index, including a <file/> tag which contains a <req/> element and a <follow/> element. Depending on whether the player has accepted or completed a mission, the server will search through the mission story indices and find appropriate replacements or additions for the story sequence. These story files are then added to the story sequence through the AddStory algorithm, or used to replace an existing story piece in the story sequence.

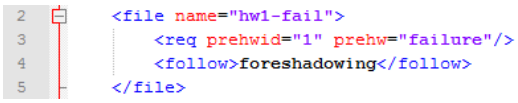

Figure 5.11. The XML representation of a mission story index

Mission Index

The missions that players are assigned to do, i.e. homework assignments in the health intervention which is incorporated in the game, are also stored in XML files on the server. Figure 5.12 shows the mission with the ID of “1”, stored in “homework.xml”.

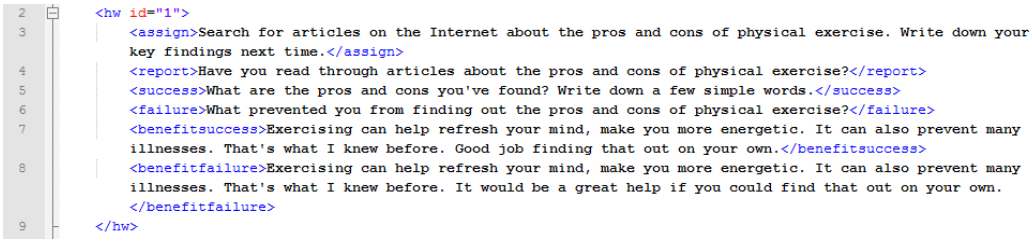

Figure 5.12. The XML representation of a mission

Each mission entry can and must have six sub-elements: <assign/>, <report/>, <success/>, <failure/>, <benefitsuccess/>, and <benefitfailure/>. Each element contains an utterance that may be used as either a text bubble or a narrator text during game play. Specifically, <assign/> contains

the utterance which is used when the mission is assigned; <report/> contains the utterance which is used when the player is prompted to report the mission; <success/> contains the utterance which is used when the player indicates the mission has been completed and is prompted to report what he or she has found; <failure/> contains the utterance which is used when the player indicates the mission has failed and is prompted to report the reason for not completing it; <benefitsuccess/> and <benefitfailure/> contain utterances which are used when the character who has assigned the mission gives a comment from the character's perspective of the question, when the player has completed or failed the mission, respectively.

Motivation Technique Index

A file named "homework-motivate.xml" on the server side contains a list of motivation technique indices categorized by each non-player character. One example, motivation techniques used by Bill Tyler, is shown in Figure 5.13.

```
<char name="bill">
    <consistency id="1">When you were first put on this mission, I thought you were
    really glad. You were going to follow this through. I can still see it in you.
    Give it a try.</consistency>
    <socialproof id="1">After the war, I was weak, and my legs were injured. I was
    like you. I went through the same set of exercises you're doing now. Trust me,
    you're doing yourself a big favor.</socialproof>
    <liking id="1">I trust you, my friend. I want you to cover my back. And for that
    I need you. You hear me? Give it a try, and I won't blame you if you fail.</liking>
    <authority id="1">I'm trying to help you, $getusername, we all are, but if it
    helps any, think of it as you work for me. It is my command that you finish your
    missions.</authority>
    <scarcity id="1">You must feel tired sometimes, but we don't really have many
    days together. Make each mission count, $getusername.</scarcity>
</char>
```

Figure 5.13. The XML representation of motivation techniques used by Bill Tyler

Each non-player character who is eligible to assign missions to the player character has access to five motivation techniques: consistency, social proof, liking, authority, and scarcity, as explained in Section 4.2.2. Each character has a unique utterance in each category. Each utterance element has an attribute named "id", which gives the system the potential of allowing each character to have more than one responses in each motivation technique category.

When the player is assigned a mission, if the player chooses to reject the mission, a motivation technique will be used, and the corresponding character's motivational utterance will be retrieved by the system and displayed as a text bubble.

Chapter 6. Evaluation of Adventures of the Atomic Submarine

The primary purpose of the DraGuNa framework is to improve player engagement with a game that incorporates this framework and to sustain player adherence to the behavior change intervention that is part of such a game. Using Adventures of the Atomic Submarine as an example game, I conducted an experiment to test the efficacy of the framework. The primary purpose of the experiment is to examine whether Adventures of the Atomic Submarine is more engaging, and its health intervention more adherent, compared to other types of behavior change interventions as well as health games developed under other types of framework. It is also important to find out whether Adventures of the Atomic Submarine can more effectively promote change in the player's health behavior, i.e. physical activity in this case, as compared to other interventions and health games. Therefore, a critical question to answer in the design of this experiment is: what are the conditions that Adventures of the Atomic Submarine should be compared against?

In healthcare, there is a growing belief that adding a game to a health intervention leads to improved outcomes and patient engagement. In Chapter 2, I examined several health games developed around a particular health issue with no specific consideration for the game design. Although many of these games were tested and some of them turned out to promote behavior change through pre-post- testing, as pointed out earlier, most of these studies have no comparison groups, or have comparison groups that do not contribute to testing whether the game added value to the intervention. These studies also tend to focus on a short scope of time in a lab setting, which fail to offer practical values (Baranowski et al. 2012). Therefore, as a first step in my experiment, I set up a study condition using a basic "game + intervention" structure, imitating prevalent games for health design. This condition can be compared to an "intervention only" condition to see what impact does simply adding a game make. To make the comparison more meaningful, this condition is constructed using the basic story of Adventures of the Atomic Submarine, but without a meaningful connection with the physical activity intervention that comes along with the game, and without a dynamic narrative structure introduced in Chapter 4.

Apart from a simple “game + intervention” architecture, a few health games adopted a strategy to encourage the player to engage in health behavior change while playing the game. For example, Escape from Diab (Lu et al. 2012) divides the game into several chapters. After playing each chapter, the game gives the player a homework assignment, which the player is given a few days to complete. These assignments usually involve eating a certain type of food for a number of meals. The player is not allowed to play the game until the number of days allocated for the assignment have passed and the player has completed the homework. This approach may force some players to engage in behavior change, but it can be perceived as a kind of punishment for not completing their homework and may damage the player’s enjoyment of the game. Therefore, I set up a condition to test this approach as well, by simply requiring the player to complete each homework before playing the game that I described in the previous paragraph.

Finally, to compare against the three game conditions, a baseline condition containing only a physical activity behavior change intervention is required. This condition is used as a basis for the three game-based conditions, because the homework assignment strategy must be the same across all conditions for the purpose of fair comparison. In the rest of this chapter, I will explain the details of each condition and the study protocol.

6.1. Study Conditions

The study is a four-condition between-subject repeated measures design. All four conditions have a common component, the homework assignment system, which is the main mechanic for delivering the physical activity behavior change intervention. Each condition contains 21 study sessions, accessible at most once per day. Therefore, a participant can theoretically complete the study in three weeks, provided that the participant accesses the study program every day. Due to the length of the program and the overlap between conditions, a within-subject design does not appear plausible. In this section, I will explain the four conditions in the order in which they are constructed on top of one another.

Homework-Only (HWNL)

The baseline condition, or the control condition, contains only homework assignments tailored to the user's physical activity stage of change. In this condition, I aim to create a minimum intervention that gives the user homework assignments based on the Trans-Theoretical Model. The homework assignments are as described in Chapter 2 and which homework assignments are given to a user is determined by the user's physical activity stage of change. When a user starts the system, he or she will be asked whether the previous homework assignment has been completed (unless this is the user's first session). Once the user types in his or her findings for the previous assignment, or explains the reasons for not completing the previous assignment, the system will present the next assignment. The user can choose to accept the assignment or reject it, in which case the system will present an alternative assignment from the pool of appropriate assignments. This sequence is depicted by Figure 5.2.

Because the Homework-Only condition will serve as the foundation for the other three conditions and will be compared to those conditions, it is important that the presentation of this system do not become a confounding factor in the comparison. Therefore, the interface of the program used in this condition is kept as close to the other conditions as possible. Because the Adventures of the Atomic Submarine was created using the Ren'Py game engine, in the form of an interactive comic, I created the Homework-Only condition program also using the Ren'Py engine, although the content is presented not in a comic book format, but in a black and white interface, as shown in Figure 6.1. The user can left-click the mouse to progress to the next slide or make a choice when prompted. The user can also press space and enter to advance the slide. These instructions are explained in the very first session of the program. To match the other conditions better, the program uses Comic-Sans, the same font used in the Adventures of the Atomic Submarine game.

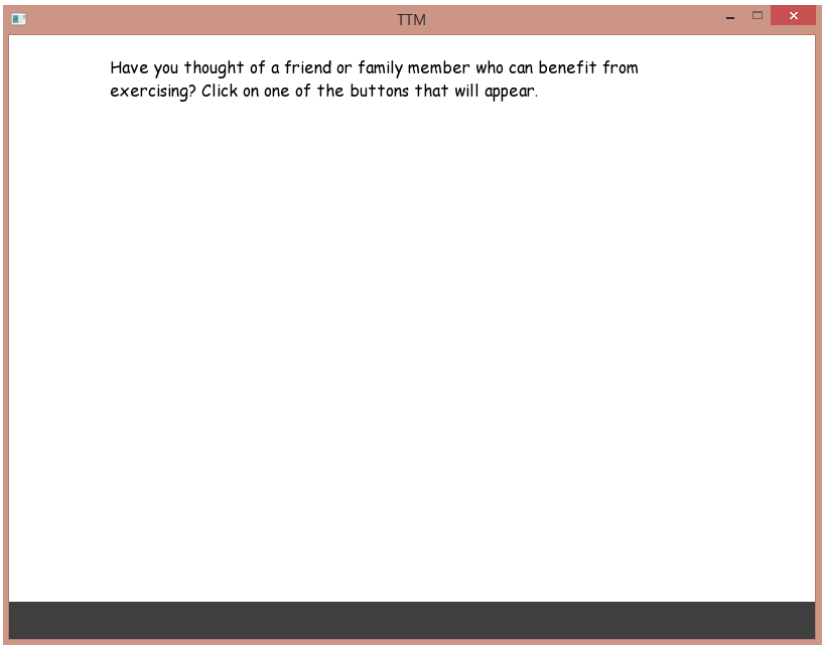

Figure 6.1. Screenshot of a Homework-Only program session

Non-Contingency (NONC)

The Non-Contingency condition explores the impact of adding game play to a health intervention. If existing games for health approaches are sound and proper, adding game play should improve the player's engagement with the software program, leading to more usage and more reported liking of the program. Therefore, the Non-Contingency condition is a simple combination of the basic story of Adventures of the Atomic Submarine and the Homework-Only intervention, i.e. there is no contingency, or logical relationship of any kind, between game play and the behavior change intervention.

When a player logs in to the Non-Contingency program, he or she will be asked whether the previous homework assignment has been completed (unless this is the player's first game session), in exactly the same way as the Homework-Only condition. After the player types in his or her findings for the previous homework or the reasons for not completing the homework, and before the player is given the next homework, the interactive comic book will be presented. The player can browse through the comic book through left-clicking, or pressing space or enter on the keyboard, in much the same way as the homework assignment portion, except in this section the player goes

through the comic book frame by frame, and page by page. When the comic book session is over, the player will be directed to the black-and-white homework assignment slide, and a new homework will be given. Figure 6.2 contains two screenshots that illustrate this process.

Figure 6.2. Screenshots of a Non-Contingency/Contingency program session

Contingency (CONT)

The Contingency condition builds on top of the Non-Contingency condition and aims to create some contingency between game play and behavior change intervention. The program in this condition follows a prevalent approach of games for health, which requires the player to perform a certain task before they can continue to play the game. In this case, the player proceeds through the game of Adventures of the Atomic Submarine in exactly the same way as in the Non-Contingency

condition, except that if the player indicates that he or she hasn't completed the previous homework assignment, the program will not allow the player to continue (except for the first session).

Full-Interaction (FULL)

The Full-Interaction condition is similar to the Non-Contingency and Contingency conditions, but it differs from the those conditions in that the Full-Interaction game uses a different type of adherence strategy by rewarding the player for their homework completion, and giving the player feedback in the game world for their failure to complete homework. Because of this increased connection between the player's homework performance and game play, the player character is allowed as well as required to be more involved in the game, where the player's homework performance has an impact on the story.

The Full-Interaction game is designed using the DraGuNa framework, in particular, using the story and the engagement and adherence techniques described in Chapter 4. In practice, the first session of the game is almost the same as in the Non-Contingency and the Contingency conditions, except that the player will be assigned a mission, instead of a homework, at the end of the session, and the mission will be assigned by one of the non-player characters as if it is a mission for the player character, who is part of the atomic commandos team. Despite the difference in the form of the homework and the mission, the content of the assignment is still the same as in the other three conditions. At the beginning of each game session except the first, the non-player character that gave the previous mission will ask the player whether he or she has completed the mission. Again, the sequence and the player's options are exactly the same as the other conditions. Only the way the question is asked has changed, as well as the use of the motivation technique, which in the Full-Interaction condition is implemented through a non-player character encouraging the player to engage in a mission, instead of an encouraging system statement in the other three conditions. The difference in the mission assignment and feedback sequence is illustrated in the screenshot in Figure 6.3. As also described in Chapter 4, satellite stories are also implemented in the Full-Interaction program: after the player completes a mission, he or she will receive a transition story,

while if the player fails to complete a mission, he or she will receive a foreshadowing story, somewhere along the game session, as selected by Algorithm AddStory.

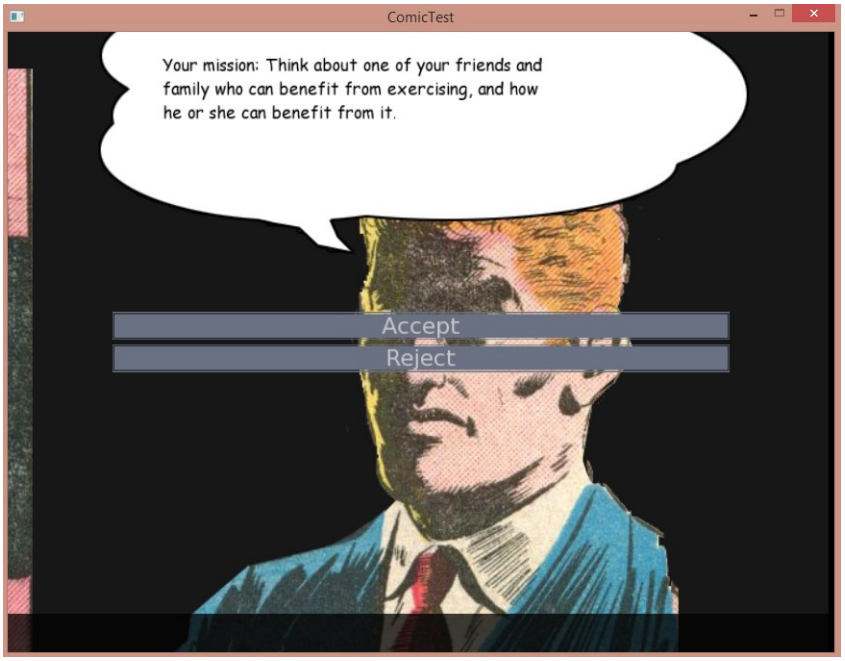

Figure 6.3. A screenshot of a Full-Interaction program session

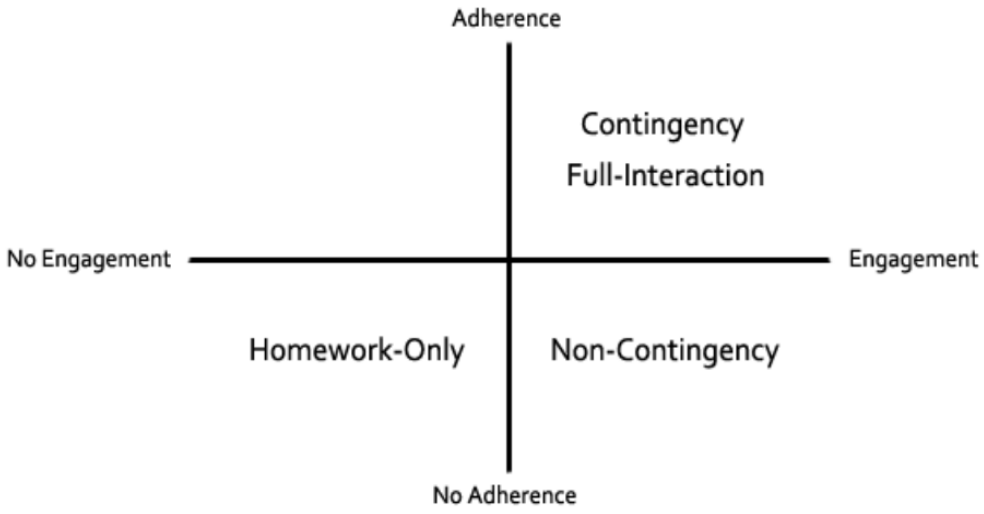

Figure 6.4. The "engagement – adherence" coordinate of the four study conditions

Except for the baseline condition which is a physical activity behavior change intervention and serves as the foundation for the other three game-based conditions, each condition can be

considered as an exploration of a quality in the “engagement – adherence” coordinate, as illustrated in Figure 6.4, although the Contingency and Full-Interaction conditions both explore the engagement and adherence axes at the same time, although their engagement and adherence strategies differ from each other.

6.2. Measures

Because the entire study is constructed on top of a physical activity behavior change intervention, it is necessary to measure the change in the user’s physical activity before and after the study. The International Physical Activity Questionnaire (IPAQ) is used for this purpose (Hagströmer et al. 2006). The IPAQ measures the amount of vigorous physical activity, moderate physical activity and walking that an individual does in a week, calculates a composite score in MET-Minutes, and categorizes the individual in three camps, 1, 2, and 3, with 1 being in a sedentary lifestyle, and 3 being actively engaged in regular physical activity. Both the number of MET-Minutes and the category of a participant is measured before and after the study. The IPAQ can be insensitive to change (Ainsworth et al. 2012), so the results from this questionnaire will be discussed with caution.

Because the homework assignments and the missions in this study are designed by following the Trans-Theoretical Model, measures related to the Trans-Theoretical Model should be assessed before and after the study. This includes the Stage of Change for exercise (Marcus et al. 1992, Norman et al. 1998), Processes of Change (Nigg et al. 1999), Self-Efficacy (Benisovich et al. 1998, Benisovich et al. 1998, Marcus et al. 1992) and Decisional Balance (Nigg et al. 1998).

The results from my previous study using a visual novel to promote patient empowerment indicate that the player’s preference for genres of video games tend to affect their reactions to the game and the study outcomes (Yin et al. 2012). Since the game used in this study highly resembles an online comic book reading experience, the participant’s preferences for comic book genres is assessed, along with their general comic book experience, age, gender, and other general information, using a Socio-demographics Questionnaire.

At the end of the study, it is important to understand the participant's attitude towards the program. A simple assessment is therefore employed at the debriefing of the study to assess the participant's liking of the program, how likely he or she is to use the program to relax, and how honest the participant is when using the program. These questions are organized together in a System Experience Questionnaire. In addition to these self-assessment questions, a Character Believability Questionnaire is also constructed following the format outlined by Riedl and Young (Riedl and Young 2005) to test whether the player is paying attention to the story, which may be an indicate of player engagement.

Besides the formal questionnaires, it is also important to understand the participant's program access pattern, homework completion rate, and issues that arise during the study. These measures can be derived from the system usage log in the database and from an interview at the end of the study. All the questionnaires can be found in Appendix D.

6.3. Study Setup

Before the study can be launched, the participant recruitment criteria must be determined. Some basic requirements include that the participant read and speak English and have access to a computer. For the three game-based conditions, it also does not make sense to include participants who clearly have a very negative attitude towards comic books, so those who indicate a strong dislike of comic books are also screened out. In addition, participants in the later Stages of Change do not have much space for improvement and are not the primary target of the game. Therefore, only individuals in the Pre-Contemplation, Contemplation and Preparation Stages of Change in terms of physical activity are recruited. However, it is also important that the participants are in such a healthy condition that they are capable of starting to exercise if they choose to. This is typically screened in the clinical setting using the PAR-Q Questionnaire (Thomas et al. 1992). Due to the large number of questions asked prior to the study, a webpage is setup where participants can be directed to check if they qualify. The same questions are also asked at the beginning of the study to ensure that participants meet these criteria. Overall, following is a summary of the study criteria:

Inclusion criteria:

- Age 18 or older.
- Understands written and spoken English (assessed by asking participants if they speak English and if they read an English language newspaper).
- Has regular access to a computer with access to the internet and can be reached by an email address.

Exclusion criteria:

- Is starting to exercise or is already exercising regularly (assessed by checking whether participants are in the Action or Maintenance stage using a one-question stage of change questionnaire at initial email or phone contact, attached).
- Is ineligible to start exercising (screened out with the PAR-Q & YOU questionnaire, attached).
- Expresses disliking of comic books or of the genre of comic book presented in the study (screened out by questions during the enrollment).

Because the entire program takes 21 days to complete, the study should allow the participants at least 21 days so that they have the time to complete the program. In the actual study, participants are allowed 28 days to use the program, because I want to give participants a better chance of completing the program to collect their feedback, and because behavior change can only be seen over a prolonged period of time. A few measures must be taken at the beginning of the study, and a few measures must be taken at the end of the study, so the study requires the participant to take part in a lab session at the beginning of the study and another lab session at the end. The first session is hence called the intake session, and the second session is hence called the debriefing session. Following is the protocol for the two sessions:

1. Written consent was obtained and the PAR-Q & YOU questionnaire was administered. If any item on the PAR-Q is not passed, the participant was asked to obtain a note from their physician stating their ability to begin a walking program and to reschedule the intake meeting once they have obtained this note.

2. The participant was seated at a desk. The experimenter administered the socio-demographics questionnaire, the IPAQ questionnaire, the self-efficacy of exercise questionnaire, the exercise decisional balance questionnaire, the exercise processes of change questionnaire, and the stage of change assessment questionnaire. (10-20 minutes)

3. Participants were told they will have access to a computer-based intervention to promote physical activity and they will receive instructions to access the intervention by email after they leave the laboratory. They were instructed to start their first session immediately in the lab and to continue to log in to the system from their computers as often as possible, up to once a day, for three to four weeks. The participant's email address were obtained. A CD was given to the participant containing the computer program, and a link to download the same program was sent to the participant by email. (20-30 minutes)

4. A debriefing session was scheduled four weeks from the intake. Participants were informed that they will receive email reminders if they do not log in to the system for several days in a row, that they will receive an email and a phone call to remind them of their debriefing session, and that they will receive compensation during the debriefing. (5 minutes)

5. Participants' game play data, including their every advancement of story and the time of such events were recorded and stored in a database on a server at Northeastern University. If the participant did not used the system for 3, 6, 10, 15, 21 days, an email reminder was sent to the participant containing information regarding their current progress in the intervention.

6. When the participant returned in four weeks, the experimenter administered again the self-efficacy of exercise questionnaire, the processes of change questionnaire, the IPAQ questionnaire, the exercise decisional balance questionnaire, the stage of change assessment questionnaire, and the system experience questionnaire. If the participant was not in the Baseline condition, the character believability questionnaire was also administered. The experimenter then turned on an audio recorder and conducted a semi-structured interview regarding their experience with the intervention (attached). (10-30 minutes)

7. The experimenter then turned off the audio recorder. Participants were informed that they can continue using the program and their data will continue to be collected until the study ends. Participants were paid and the session is terminated. (5 minutes)

8. A week before the conclusion of the study, an email was sent to all participants stating that the server will be shut down in a week and the game will become inaccessible.

6.4. Hypotheses

The primary goal of this study is to investigate whether the DraGuNa framework used in creating the Full-Interaction condition of the Adventures of the Atomic Submarine will lead to its players having a higher level of engagement and adherence and gaining more benefits from the intervention. However, a few other hypotheses are also made based on the design of the study.

First, since the Trans-Theoretical Model is applied as the theoretical foundation of the game-based intervention, I hypothesize that players' physical-activity-related behaviors will increase significantly throughout the study according to the TTM. Therefore, hypotheses H1a through H1d are made.

H1a: Participants' pre-post measures of total physical activity as measured by IPAQ MET-Minutes, and physical-activity-related TTM measures, including Stage of Change, Self-Efficacy, Processes of Change, and Decisional Balance will improve significantly throughout the study for all 4 treatment groups.

H1b: The number of homework assignments completed by a participant should have a significant positive effect on the participant's change in Processes of Change for all 4 treatment groups.

H1c: A participant's change in Processes of Change should have significant positive effects on the participant's change in Stage of Change, Decisional Balance and Self-Efficacy for all 4 treatment groups.

H1d: A participant's change in Stage of Change, Decisional Balance and Self-Efficacy should have significant positive effects on the participant's change in total physical activity for all 4 treatment groups.

Let us now examine our manipulations of the four conditions. First, applying engagement techniques in a health game should make it more enjoyable to the player and make the player want to continue playing the game. In the study design, the Non-Contingency condition should be more engaging than the Homework-Only condition, and the Full-Interaction condition should be more engaging than all the other conditions. The outcome should be reflected in the number of sessions completed by players. Therefore, hypotheses H2a and H2b are made.

H2a: The number of sessions participants complete in the Non-Contingency condition will be significantly more than in the Baseline condition.

H2b: The number of sessions participants complete in the Full-Interaction condition will be significantly more than in the other three conditions.

Also, conditions with adherence techniques are hypothesized to incur a higher homework completion rate from the users. This can be reflected in a number of ways, but in this work, I've chosen the percentage of homework assignments completed in the total number of homework assignments the user has been assigned. Thus hypotheses H3a and H3b are made.

H3a: The percentage of assigned homework completed in the Contingency condition will be significantly more than in the Baseline and Non-Contingency conditions.

H3b: The percentage of assigned homework completed in the Full-Interaction condition will be significantly more than in the other three conditions.

The above hypotheses indicate a relationship between study condition and change in physical activity, potentially through the mediation of several other factors. Therefore, I hypothesize that an impact of study condition on the change in physical activity should also be observed. Therefore, hypotheses H4a and H4b are made.

H4a: Participants in the Non-Contingency and Contingency conditions will experience significantly more physical activity gain than participants in the Homework-Only condition.

H4b: Participants in the Full-Interaction condition will experience significantly more physical activity gain than participants in the other conditions.

Chapter 7. Findings from the Experiment

The study commenced from early August through the end of December in 2014. Participants were recruited through flyers around university campuses in Boston, online event advertisement through Northeastern University, and ads on craigslist.org. A total of 120 participants were enrolled in the study, out of which 96 participants returned for the debriefing session (80%). Most participants who did not come back for the debriefing completed no session beyond the first session in the lab. Figure 7.1 is a consort diagram of the study.

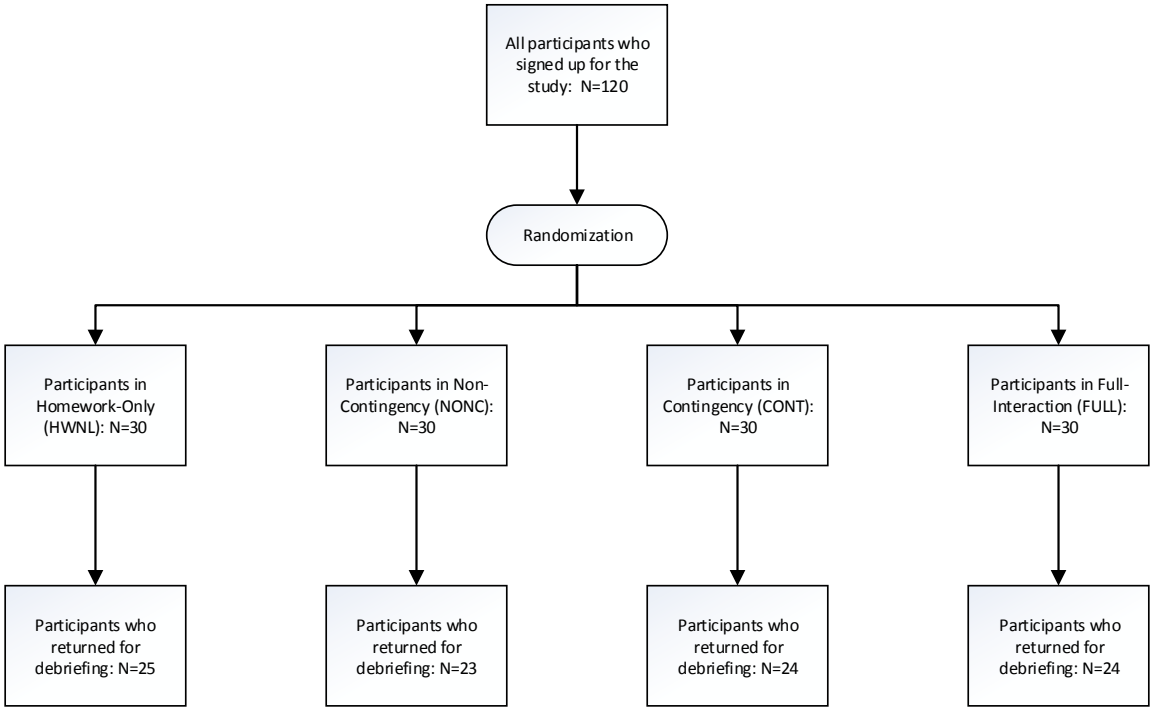

Figure 7.1. Consort diagram of the study.

7.1. Participants

The age of the participants range from 18 to 58, among which 101 (84.1%) are 25 or younger. Only 6 participants (5%) are above 40 years old. Figure 7.2 illustrates the participants' age distribution. Among the participants, 67 (55.8%) are male. 62 participants (51.6%) identify as Asian or Pacific Islander, 43 (35.8%) identify as Anglo-American or European, not of Hispanic Origin, 11 (9.1%) as

African American or Black, and 4 (3.3%) as Hispanic/Latino. The majority of participants are single: 117, or 97.5%. The majority of participants are also students: 106, or 88.3%, part of which (9, or 7.5%) also have a job, while 11 participants (9.1%) have a variety of occupations, and 3 (2.5%) are unemployed. In terms of education, 25 participants (20.8%) are high school graduates, 2 (1.6%) have a technical school education, 37 (30.8%) have completed some college, 49 (40.8%) have graduated college, and the other 7 (5.8%) have advanced degrees. Figure 7.3 illustrates the participants' education distribution.

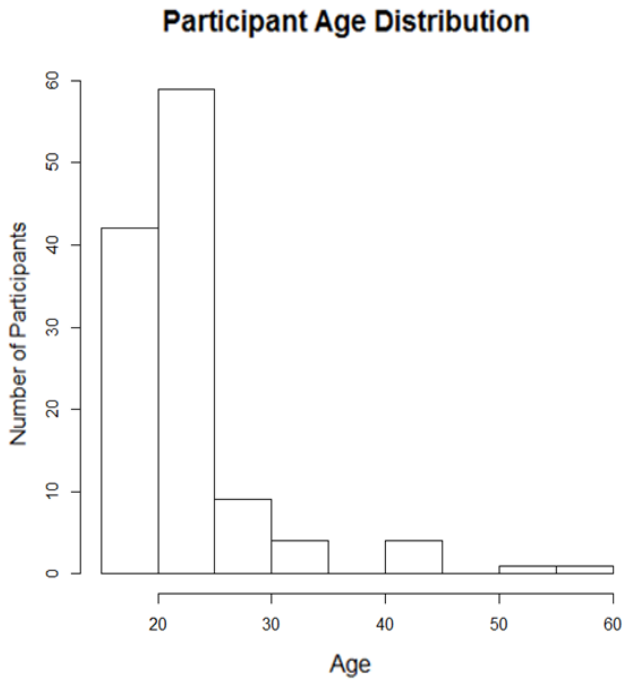

Figure 7.2. Participant age distribution

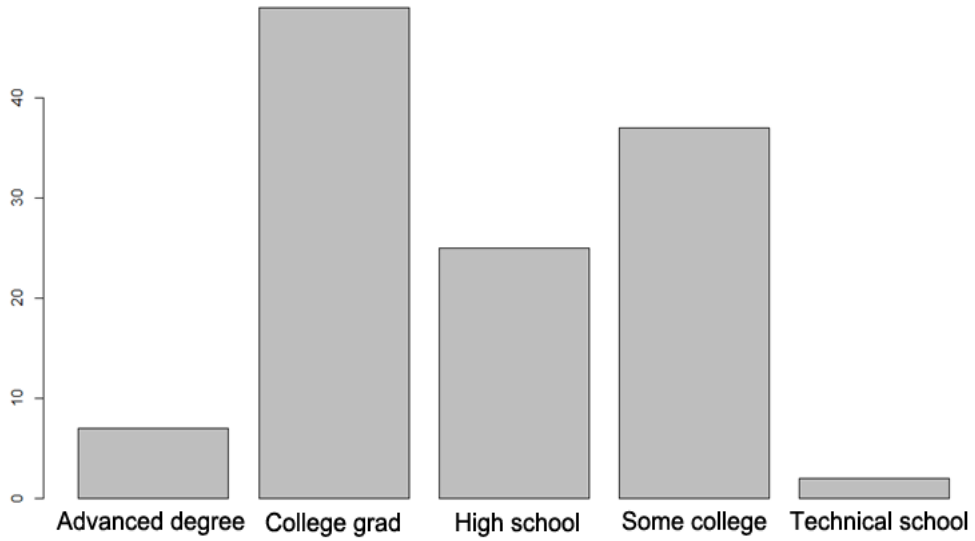

Figure 7.3. Participant education distribution

The participants' socio-demographic data are tested for homogeneity by study condition. ANOVA is conducted on the participants' age, gender, ethnicity, marital status, education, occupation (student vs. non-student), reading frequency, computer experience, liking of computers, comic book experience, liking of comic books, and preference for the eight genres of comic books (adventure, fantasy, horror, humor, romance, sci-fi, superhero, and war/forces). Tables 7.1 and 7.2 show the descriptive statistics as well as the ANOVA test results. None of the above measures is significant except that for preference of romance comic books, where more participants who prefer the genre have been recruited in the Contingency and Full-Interaction conditions, and the difference is near significance: $F(3,92)=2.58$, $p<.1$. ANOVA tests are also performed on participants' pre-test behavior measures, including Total Physical Activity, Stage of Change, Processes of Change, Self-Efficacy, and Decisional Balance. No significant difference is shown, as illustrated in Table 7.3.

Measure	*HWNL*	*NONC*	*CONT*	*FULL*	*Returned*	*Withdrawn*
Age, mean±SD	23.62±7.14	23.21±6.39	23.62±7.14	23.62±8.13	23.23±6.39	24.08±6.76

Female, n(%)	13 (52.0)	9 (39.1)	12 (50.0)	8 (33.3)	42 (43.7)	11 (45.8)
Race, n(%)						
Asian	15 (60.0)	11 (47.8)	13 (54.1)	12 (50.0)	51 (53.1)	11 (45.8)
Anglo-American	2 (8.0)	4 (17.3)	6 (25.0)	3 (12.5)	15 (15.6)	4 (16.6)
Black	2 (8.0)	3 (13.0)	0 (0.0)	2 (8.3)	7 (7.2)	4 (16.6)
European	4 (16.0)	4 (17.3)	5 (20.8)	7 (29.1)	20 (20.8)	4 (16.6)
Hispanic	2 (8.0)	1 (4.3)	0 (0.0)	0 (0.0)	3 (3.1)	1 (4.1)
Married, n(%)	1 (4.0)	0 (0.0)	2 (8.3)	0 (0.0)	3 (3.1)	0 (0.0)
Education, n(%)						
High School	6 (24.0)	3 (13.0)	5 (20.8)	7 (29.1)	21 (21.8)	4 (16.6)
Technical School	1 (4.0)	0 (0.0)	0 (0.0)	1 (4.1)	2 (2.0)	0 (0.0)
Some College	7 (28.0)	8 (34.7)	11 (45.8)	4 (16.6)	30 (31.2)	7 (30.4)
College	10 (40.0)	10 (43.4)	7 (30.4)	10 (41.6)	37 (38.5)	12 (50.0)
Advanced Degree	1 (4.0)	2 (8.6)	1 (4.3)	2 (8.3)	6 (6.2)	1 (4.3)
Student, n(%)	23 (92.0)	21 (91.3)	20 (83.3)	22 (91.6)	86 (89.5)	19 (76.1)
Reading Frequency, *mean±SD*	3.20±1.04	3.17±1.15	3.58±1.21	3.45±1.21	3.35±1.15	3.17±1.27
Computer Experience, *mean±SD*	3.36±0.48	3.21±0.42	3.25±0.44	3.41±0.50	3.31±0.46	3.08±0.58

Computer Liking, *mean±SD*	3.60±0.50	3.65±0.48	3.58±0.50	3.79±0.41	3.66±0.47	3.54±0.58
Comic Experience, *mean±SD*	2.32±0.74	2.34±0.64	2.16±0.63	2.20±0.41	2.26±0.62	2.42±0.77
Comic Liking, *mean±SD*	3.16±0.74	2.95±0.82	2.91±0.50	3.16±0.63	3.05±0.68	3.08±0.71

Table 7.1. Socio-demographic measures of participants. No significant difference is found between groups, but computer experience is significantly different between returning participants and withdrawn participants.

Genre	*HWNL*	*NONC*	*CONT*	*FULL*	*Returned*	*Withdrawn*
Adventure, n(%)	18 (72.0)	16 (69.5)	19 (79.1)	22 (91.6)	75 (78.1)	17 (70.8)
Fantasy, n(%)	14 (56.0)	9 (39.1)	13 (54.1)	14 (58.3)	50 (52.0)	11 (45.8)
Horror, n(%)	6 (24.0)	6 (26.0)	4 (16.6)	4 (16.6)	20 (20.8)	5 (20.8)
Humor, n(%)	14 (56.0)	18 (78.2)	13 (54.1)	16 (66.6)	61 (63.5)	15 (62.5)
Romance, n(%)	3 (12.0)	2 (8.6)	8 (33.3)	8 (33.3)	21 (21.8)	6 (25.0)
Sci-Fi, n(%)	13 (52.0)	13 (56.5)	15 (62.5)	16 (66.6)	57 (59.3)	14 (58.3)
Superhero, n(%)	13 (52.0)	9 (39.1)	14 (58.3)	13 (54.1)	49 (51.0)	15 (62.5)
War/Force, n(%)	8 (32.0)	8 (34.7)	6 (25.0)	5 (20.8)	27 (28.1)	5 (20.8)

Table 7.2. Number of participants who prefer each genre by condition. Only preference for romance comics is near significantly different among the four study conditions.

Measure	*HWNL*	*NONC*	*CONT*	*FULL*	*Returned*	*Withdrawn*

Total P.A., mean±SD	1459.96 ±1159.34	1501.86 ±1394.78	1081.70 ±1288.12	1587.41 ±1593.31	1407.22 ±1358.03	2375.39 ±3216.88
Stage of Change, mean±SD	3.56±0.58	3.86±0.62	3.83±0.48	3.83±0.63	3.77±0.58	3.67±0.70
Self-Efficacy, mean±SD	47.52 ±14.46	51.78 ±12.53	45.33 ±14.40	45.20 ±14.40	47.42 ±13.64	49.62 ±15.13
Processes of Change, mean±SD	82.04 ±14.83	84.56 ±18.97	73.41 ±13.69	77.83 ±19.76	79.44 ±17.22	79.63 ±18.60
Decisional Balance, mean±SD	8.32±4.87	7.91±5.23	5.33 ±5.39	5.54±5.54	6.78±5.35	8.54±5.55

Table 7.3. Pre-study TTM measures of participants. No significant difference is discovered among conditions, but significant differences are found between returning participants and those withdrawn on pre-test physical activity.

Participants who returned for the debriefing session are also compared to participants who did not complete the debriefing on the same measures mentioned above. Independent samples t-tests are used for these analyses, and significant differences are found on participants' computer experience and pre-test physical activity. There is a significant difference in computer experience between participants who returned to the debriefing session (M=3.31, SD=0.46) and participants who did not return (M=3.08, SD=0.58): participants who returned have significantly higher computer experience than those who did not; $t(118) = 2.04$, $p<.05$. There is also a significant difference in pre-test physical activity score between participants who returned to the debriefing (M=1407.22, SD=1358.03) and those who did not (M=2375.39, SD=3216.88): participants who did not return did significantly more physical activity when they enrolled in the study than the participants who returned to the debriefing; $t(118) = 2.26$, $p<.05$. One explanation is that participants who were already exercising felt they did not need the program, provided that they were also in the Pre-Contemplation, Contemplation and Preparation Stages of Change, and homework assignments that are not actual physical-activity-oriented perhaps did not help them achieve more exercise goals.

Another possibility is that, as several participants' IPAQ questionnaires revealed, some participants' physical activity mainly came from labor work, and these participants are also students.

7.2. Hypothesis Testing

To test hypothesis H1a, paired-samples t-tests are run to examine the change in participants' physical activity and TTM measures before and after the study, across all four conditions. Table 7.4 shows the results of the tests.

Pre-Post Variable	T-Score	D Value	P Value	
Total MET-minutes of physical activity	6.16	0.74	1.71E-08	***
Stage of Change	8.06	0.40	2.16E-12	***
Self-Efficacy	2.14	0.219	0.03	.
Processes of Change	9.17	0.93	9.71E-15	***
Decisional Balance (pros)	5.54	0.58	2.68E-07	***
Decisional Balance (cons)	0.63	0.06	0.52	
Decisional Balance (pros vs. cons)	4.19	0.42	6.12E-05	***

Signif. codes: '*' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1**

Table 7.4. Paired-samples t-tests on physical activity and behavior change measures across all 4 treatments. For all measures, df=95.

When vigorous, moderate intensity, and walking MET-minutes were tested separately, significant changes were also found across all the conditions. Paired-samples t-tests show that participants experienced significant increases in their vigorous physical activity from before (M=183.13, SD=453.37) to after the study (M=837.76, SD=1429.09); $t(95) = 4.39$, $p<.001$, $d = 0.51$, significant increases in moderate intensity physical activity from before (M=311.77, SD=654.32) to after (M=900.09, SD=1499.75); $t(95) = 3.84$, $p<.001$, $d = 0.43$, and significant increases in their walking as well, from before (M=912.33, SD=876.55) to after (M=1751.58, SD=1692.83); $t(95) = 5.48$, $p<.001$, $d = 0.63$.

Specifically, to test the clinical significance of the change, the 2007 CDC physical activity recommendations are used as a standard, which suggests 450 to 750 MET-minutes of combined moderate-intensity and vigorous physical activity per week for healthy adults between 18 and 65 years (Haskell et al. 2007). Participants in the study had a significant increase in their combined moderate-intensity and vigorous activities before (M=494.89, SD=812.25) and after (M=1737.85,

SD=2396.76); t(95) = 5.08, p<.001, d = 0.60. The mean of participants' MET-minutes per week before the study was at the lower end of the recommended amount of exercise, and by the end of the study their MET-minutes increased to more than double the higher end of recommended exercise. The change also exceeded Cohen's convention (Cohen 2013) of medium effect size.

Paired-samples t-tests were also performed on participants in each condition to ensure that participants in all conditions experience improvements in their behavior change. Table 7.5 demonstrates the results of these t-tests.

Pre-Post Variable	**HWNL**			**NONC**			**CONT**			**FULL**		
	T	D	P	T	D	P	T	D	P	T	D	P
Total MET-minutes of physical activity	3.55	1.03	<0.01	1.01	0.21	n.s.	3.67	1.14	<0.01	2.39	0.92	<0.05
Stage of Change	4.04	0.82	<0.001	4.49	1.28	<0.001	4.45	0.98	<0.001	4.01	0.77	<0.001
Self-Efficacy	2.43	0.47	<0.05	1.33	0.27	n.s.	0.61	0.12	n.s.	0.26	0.05	n.s.
Processes of Change	8.54	1.73	<0.01	3.91	0.82	<0.001	4.61	0.95	<0.001	3.13	0.64	<0.01
Decisional Balance (pros)	3.84	0.85	<0.001	3.71	0.79	<0.01	2.27	0.38	<0.05	1.69	0.34	<0.1
Decisional Balance (cons)	0.79	0.16	n.s.	2.79	0.60	<0.05	0.44	0.09	n.s.	1.88	0.39	<0.1
Decisional Balance (pros vs. cons)	2.09	0.42	<0.05	1.51	0.32	n.s.	2.39	0.49	<0.05	2.25	0.46	<0.05

Table 7.5. Paired-samples t-tests on physical activity and behavior change measures for each condition. T is the t statistic, and D is Cohen's d.

It is clear that most of the measures saw significant improvements during the study period. Change in physical activity had a medium effect size, d = 0.75 (Cohen 2013), change in Processes of Change had a large effect size, and change in Stage of Change, Self-Efficacy and Decisional Balance had a small effect size. However, note that in the Non-Contingency condition, participants' perceived importance of cons of physical activity, as part of Decisional Balance, increased, which is a negative change, while the measure decreased in all other conditions, a positive change. Also, participants in the Non-Contingency condition did not see significant improvements in physical activity, in contrast to all the other conditions, where the effect size of change in physical activity in each condition exceeded a large effect size. These findings suggest that participants who completed the study experienced significant gains in physical activity and in exercise-related behavior change, and therefore hypothesis H1a is supported. However, this change is not as clear for participants in the Non-Contingency condition as in the other three conditions.

To test H1b through H1d, a series of regressions are performed: First, the number of homework assignments completed significantly predicts change in Processes of Change, $\beta=0.18$, $t(94) = 1.86$, $p<.1$, and the number of homework assignments completed explains a near significant proportion of variance in change in Processes of Change, $R^2 = 0.03$, $F(1,94) = 3.48$, $p < .1$. This supports H1b.

Change in Processes of Change significantly predicts change in Stage of Change, $\beta=0.23$, $t(94) = 2.28$, $p<.05$, and change in Processes of Change explains a significant proportion of variance in change in Stage of Change, $R^2 = 0.05$, $F(1,94) = 5.24$, $p<.05$. Change in Processes of Change also significantly predicts change in Self-Efficacy, $\beta=0.32$, $t(94) = 3.93$, $p<.001$, and change in Processes of Change explains a significant proportion of variance in change in Stage of Change, $R^2 = 0.13$, $F(1,94) = 15.46$, $p<.001$. Finally, change in Processes of Change significantly predicts change in Decisional Balance, $\beta=0.42$, $t(94) = 4.59$, $p<.001$, and change in Processes of Change explains a significant proportion of variance in change in Stage of Change, $R^2 = 0.17$, $F(1,94) = 21.09$, $p<.001$. Therefore, H1c is fully supported.

Change in Stage of Change significantly predicts change in participants' total physical activity, $\beta=0.47$, $t(94) = 5.19$, $p<.001$, and change in Stage of Change predicts a significant proportion of

variance in change in physical activity, R^2 = 0.22, F(1,94) = 26.98, p<.001. However, change in Self-Efficacy does not significantly predict change in participants' total physical activity, β=0.03, t(94) = 0.33, n.s., and change in Decisional Balance does not significantly predict change in participants' total physical activity.

Hypotheses H2a and H2b are concerned with **engagement**: participants' use of the program. Participant's use of the program, i.e. total sessions completed, is subject to a ceiling effect, with a maximum 21 sessions. The distribution is therefore negatively skewed (see Figure 7.4), and thus a Kruskal-Wallis test is done to compare the participants' total completed sessions between Homework-Only (M=14.72, SD=6.04), Non-Contingency (M=13.69, SD=6.73), Contingency (M=12.29, SD=5.84), and Full-Interaction (M=14.54, SD=7.40). The result is non-significant; $\chi^2(3)=2.32$, p=n.s. However, qualitative analysis from the interviews revealed a difference in participants' reactions to the program between genders (explored in more detail in Section 7.4.1), and therefore an analysis is performed to test the interaction effect between study condition and gender on total number of sessions completed. To perform this analysis, total number of sessions data are first ranked using the Aligned Rank Transform tool (Wobbrock et al. 2011). Then, a two-way ANOVA is run to examine the interaction effect between condition (HWNL: M=14.72, SD=6.04; NONC: M=13.69, SD=6.73; CONT: M=12.29, SD=5.84; FULL: M=14.54, SD=7.40) and gender (Male: N=54, M=14.01, SD=7.02; Female: N=42, M=13.57, SD=5.82). The test shows a significant interaction effect between condition and gender on the number of sessions; F(3,88) = 3.64, p<0.01, η^2 = 0.02, with a small effect size. Separate Kruskal-Wallis tests on the pre-transformation data show that among male participants, those in the Full-Interaction condition finished near significantly more sessions compared to participants in the other conditions; $\chi^2(3)=6.49$, p<0.1 , whereas for females, those in the Homework-Only condition completed near significantly more sessions than the other sessions; $\chi^2(3)=7.10$, p<0.1. This effect is shown in Figure 7.5, where the y-axis shows means of total finished sessions before the transformation. Therefore, H2b is supported only for male participants, and H2a is not supported.

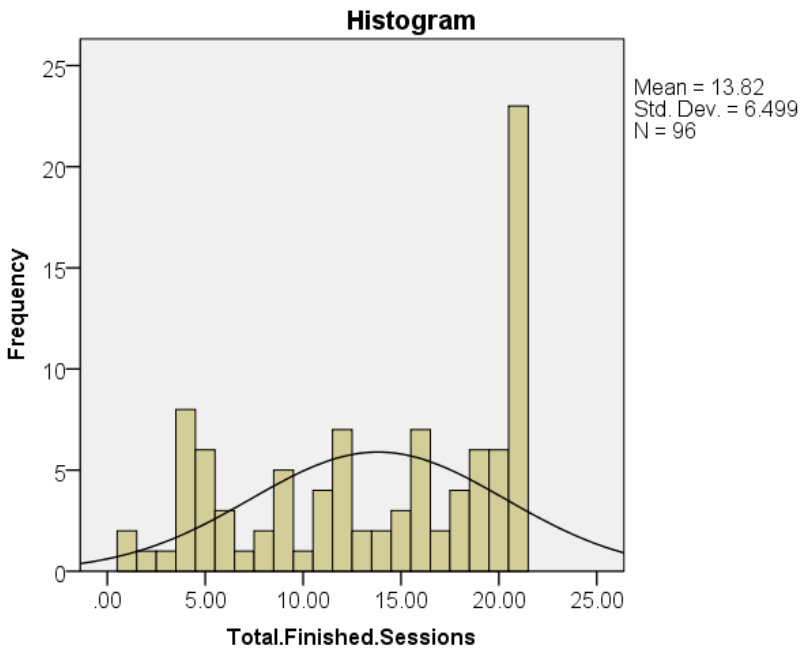

Figure 7.4. Distribution of total finished sessions

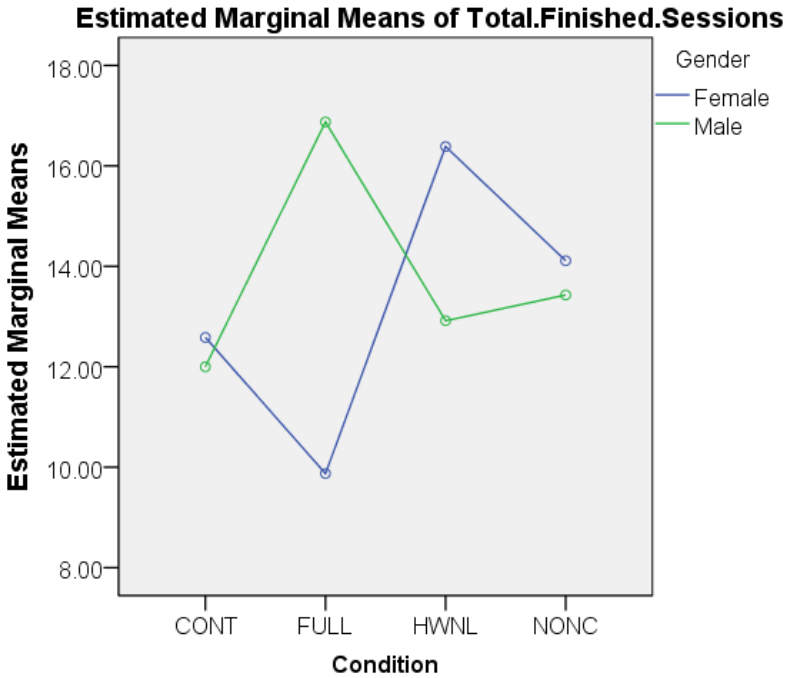

Figure 7.5. Interaction effect between condition and gender on total finished sessions.

Figure 7.6 is a box plot of the number of sessions completed by a single participant by study condition. Figure 7.7 shows the predicted probability of user login in each condition in 80 days. This regression is performed over 80 days instead of 28 days because in the Full-Interaction condition, some participants continued to play the game up to Day 78. The plot shows that participants in the Contingency condition has a significantly lower probability of login, as is demonstrated in Table 7.6 as well. It is also noteworthy that a few participants in the Full-Interaction condition continued to log in long after the debriefing session, a phenomenon not seen in any of the other conditions.

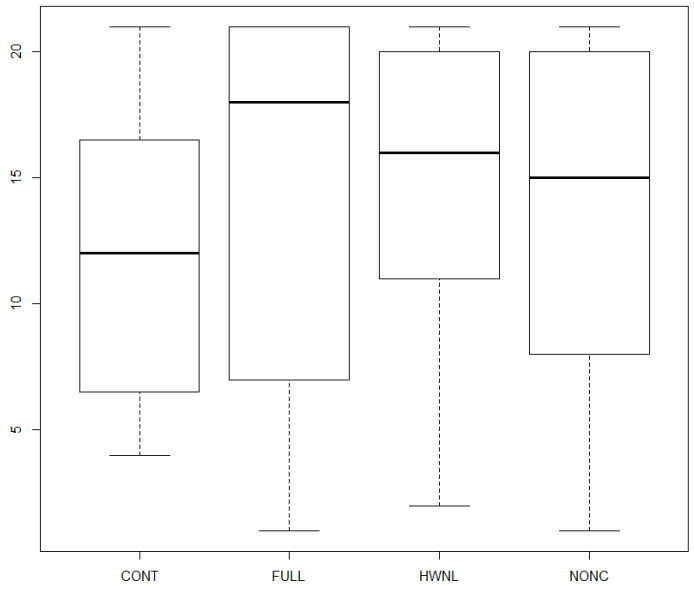

Figure 7.6. Number of sessions completed by condition.

X-axis: study condition; Y-axis: number of sessions completed.

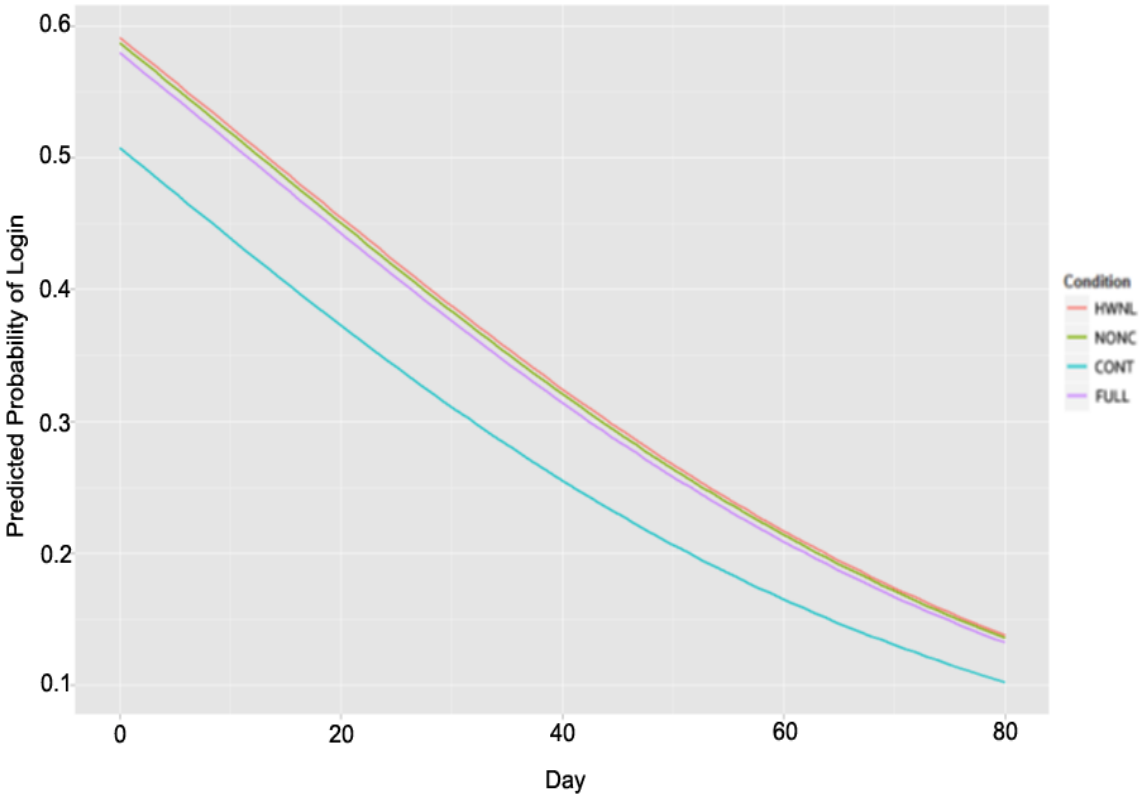

Figure 7.7. Probability of login on each day by condition.

	Estimate	Std. Error	z-score	P value
(Intercept)	0.36873	0.084621	4.357	1.32E-05
Day	-0.027537	0.002975	-9.255	< 2e-16
NONC	-0.017221	0.108907	-0.158	0.87436
CONT	-0.338153	0.105913	-3.193	0.00141
FULL	-0.048333	0.105643	-0.458	0.6473

Table 7.6. Results of a logistic regression on the effect of condition and study day on participant's probability of login.

Hypotheses H3a and H3b are concerned with **adherence**: The percentage of homework completed in all homework assigned is used for this analysis. Tables 7.7 and 7.8 show the number of homework assignments completed in each Process of Change, and the number of homework assignments failed in each Process of Change, by all users in a specific Stage of Change. The program chooses homework assignments evenly across all applicable Processes of Change for each participant, so it can be observed that participants in each Stage of Change completed homework assignments from each Process of Change somewhat equally. However, participants in the Contemplation Stage of Change failed a disproportionally large number of homework assignments in the Consciousness Raising Process of Change, and the participants in Preparation failed a large amount of homework in Self-Reevaluation. Observing that Consciousness Raising is shared between Pre-Contemplation and Contemplation, and Self-Reevaluation is the only Process of Change shared between Contemplation and Preparation, it may be that participants felt the homework in these Processes of Change were too easy for them, since they've already moved on to the next Stage of Change, and thus they decided to ignore the homework.

	Pre-Contemplation	*Contemplation*	*Preparation*
Consciousness Raising	27 (30.6%)	172 (22.5%)	N/A
Dramatic Relief	23 (26.1%)	165 (21.6%)	N/A
Environmental Reevaluation	21 (23.8%)	158 (20.7%)	N/A
Social Liberation	17 (19.3%)	139 (18.2%)	N/A
Self-Reevaluation	N/A	129 (16.9%)	123 (26.5%)
Self-Liberation	N/A	N/A	131 (28.2%)
Helping Relationships	N/A	N/A	117 (25.2%)
Counter Conditioning	N/A	N/A	93 (20.0%)

Table 7.7. Number (percent) of total completed homework assignments in each Process of Change by participant's Stage of Change.

	Pre-Contemplation	*Contemplation*	*Preparation*
Consciousness Raising	0 (0%)	17 (47.2%)	N/A
Dramatic Relief	0 (0%)	6 (16.6%)	N/A
Environmental Reevaluation	0 (0%)	4 (11.1%)	N/A
Social Liberation	2 (100.0%)	6 (16.6%)	N/A
Self-Reevaluation	N/A	3 (8.3%)	12 (41.3%)
Self-Liberation	N/A	N/A	5 (17.2%)
Helping Relationships	N/A	N/A	7 (24.1%)
Counter Conditioning	N/A	N/A	5 (17.2%)

Table 7.8. Number (percent) of total failed homework assignments in each Process of Change by participant's Stage of Change.

Figure 7.8 is a box plot of participants' homework completion rate by a single participant by study condition. A Kruskal-Wallis test shows no significant difference between the study conditions (HWNL: M=0.95, SD=0.06; NONC: M=0.88, SD=0.13; CONT: M=0.94, SD=0.11; FULL: M=0.93, SD=0.09) on homework completion rate; $\chi^2(3)=2.30$, p=n.s. However, a clear trend can be observed in Figure 7.9 that participants in the Non-Contingency condition completed much less homework than participants in the other conditions. A follow-up Mann-Whitney test comparing Non-Contingency (N=23, M=0.88, SD=0.13) against the other conditions combined (N=73, M=0.94, SD=0.09) reveals a significant difference on the percentage of homework assignments completed, where participants in the Non-Contingency condition completed less assignments than the other conditions; Mann-Whitney U=611.50, $p<0.05$. Although homework completion rate is not significantly higher in Contingency and in Full-Interaction compared to the other conditions, they are significantly higher than in the Non-Contingency condition, and therefore H3a and H3b are partially supported.

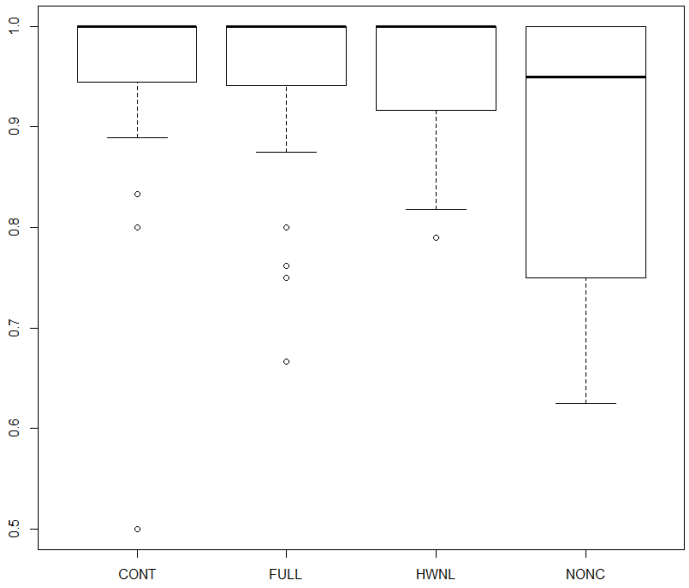

Figure 7.8. Percentage of homework assignments completed by condition.

X-axis: study condition; Y-axis: homework completion rate.

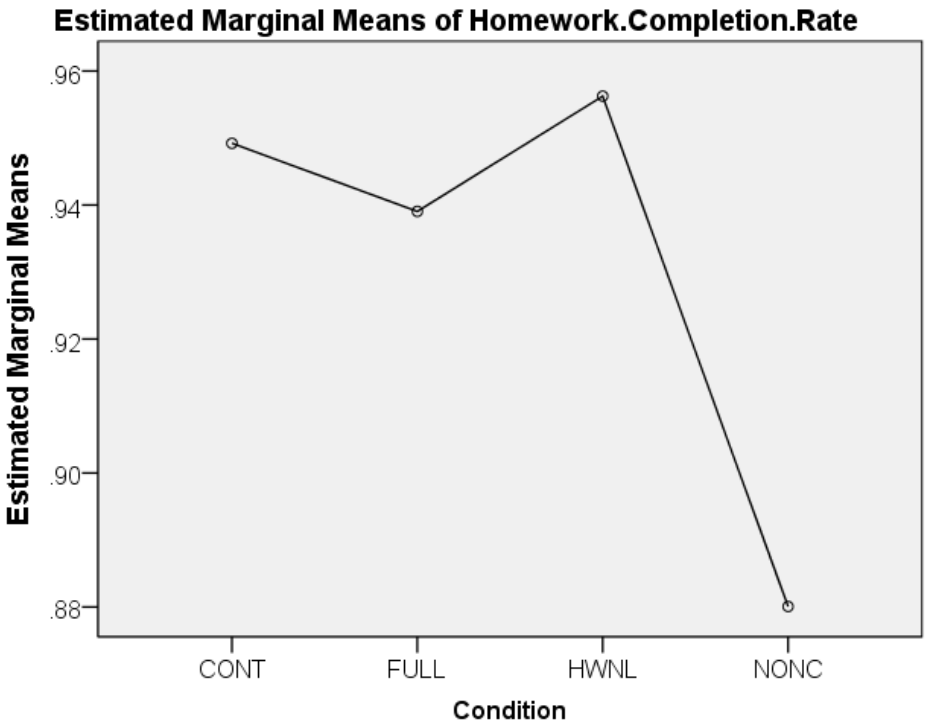

Figure 7.9. Effect of study condition on homework completion rate

An ANOVA is run to test hypotheses H4a and H4b by examining the effect of study condition on change in physical activity. The analysis reveals that study condition (HWNL: M=2120.52, SD=642.26; NONC: M=542.98, SD=669.60; CONT: M=2287.18, SD=655.50; FULL: M=3312.25, SD=655.50) does have a significant effect on change in physical activity; $F(3,92) = 2.96$, $p<0.05$, $\eta^2 = 0.06$. However, the only significant difference is that Non-Contingency underperformed Full-Interaction, although the trend shows that Full-Interaction tends to outperform all the other conditions. Therefore, hypothesis H4a is not supported, but H4b is supported. Figure 7.10 illustrates this effect. Due to the findings in previous hypothesis tests, I also tested the interaction effect between study condition and gender (Male: M=2470.62, SD=3727.49; Female: M=1582.73, SD=2639.23) on change in physical activity, and no significance is found; $F(3,88) = 0.52$, n.s.

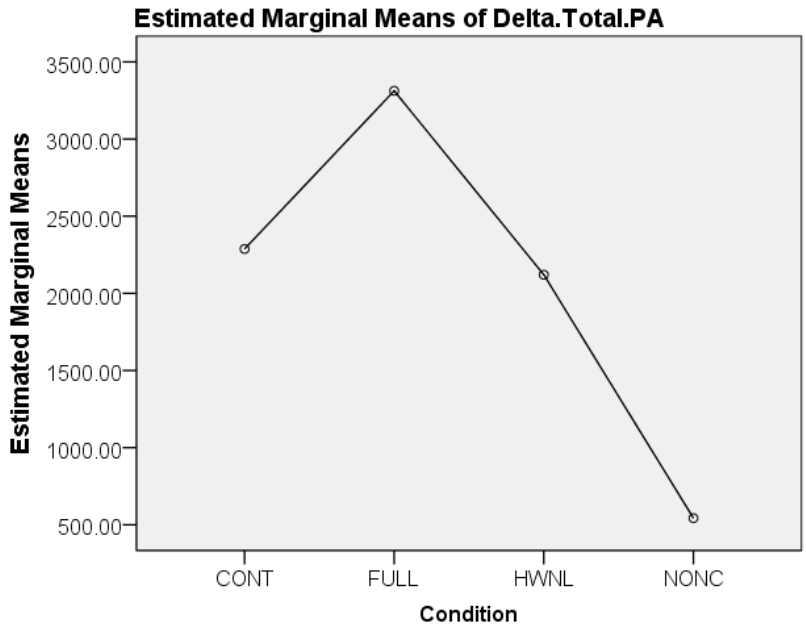

Figure 7.10. Effect of study condition on change in physical activity.

With the information that emerged through the analysis, a causal model can be formed as illustrated in Figure 7.11.

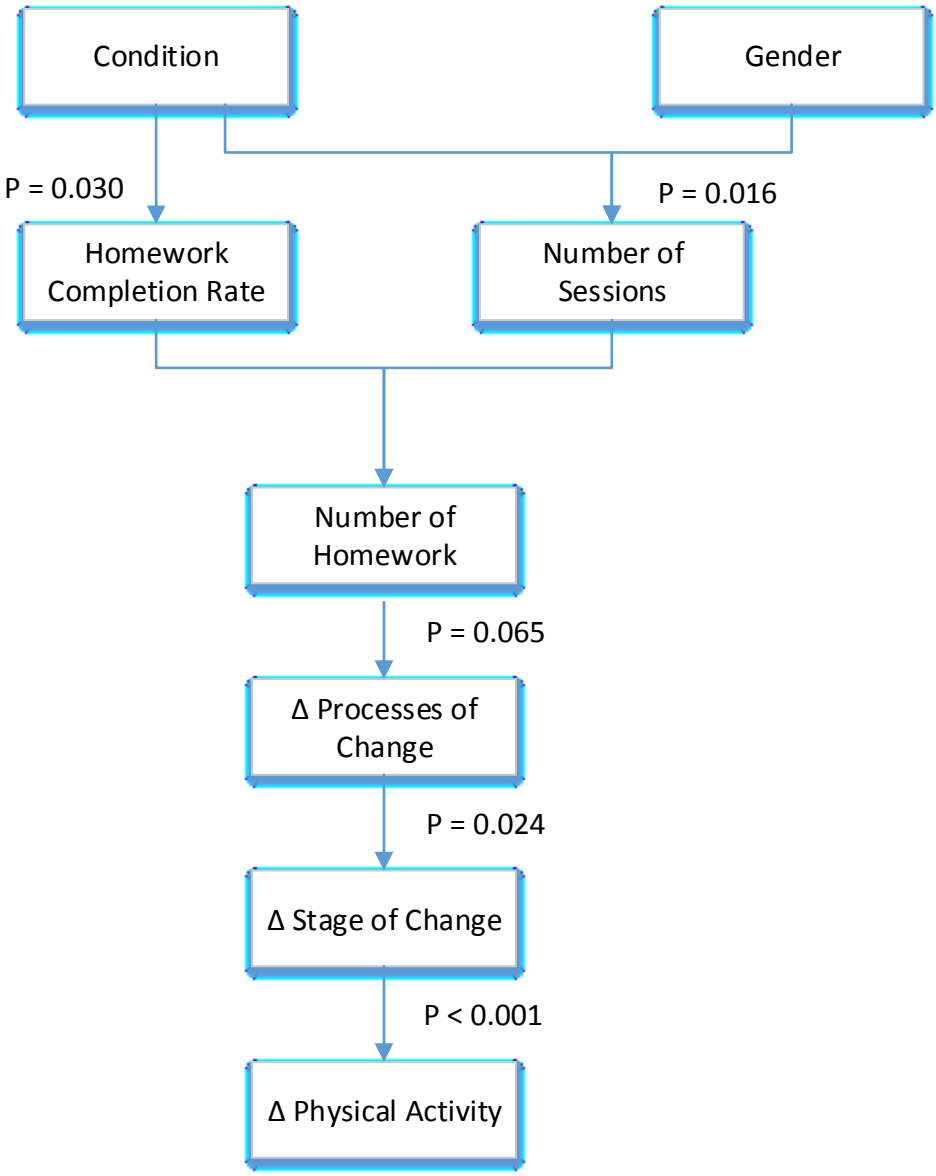

Figure 7.11. Final Flowchart of the effect of engagement and adherence on change in physical activity

This model and the hypothesis testing suggest that, as hypothesized, the application of adherence and engagement techniques impact the rate that users play a health game and the rate that users complete homework assignments in the health-game-based intervention, although gender also plays a role in the type of intervention an individual prefers.

This model also confirms that the relationships between the number of homework assignments completed, change in Processes of Change, change in Stage of Change, and change in an individual's physical activity are as the Trans-Theoretical Model dictates across all conditions of the study, except that some of these relationships do not hold true in the Non-Contingency condition. Therefore, this study cannot confirm that health games have a universal superior effect over conventional, message-based health interventions, on participants' engagement with the program and their adherence to it, and the important message is that a health professional designing a behavior change intervention must decide carefully whether the intervention should take on the form of a game.

7.3. Exploratory Analyses

The analyses in this section are purely exploratory. With uncorrected alpha, some of these results are likely spurious due to the possibility of inflated Type I error. However, these analyses make for important discussion and point the way to future work.

An important aspect of the study that must be discussed is gender effect, given that it has been discovered to play an important role in the main hypotheses. I also expand this analysis to the other socio-demographics measures. My previous study has shown that an individual's favorite genre of games can have a significant impact on their gain from playing a health game (Yin et al. 2012). Socio-demographic information may have a significant impact on the outcomes of this study as well, and therefore the effects of socio-demographics on the participants' system usage, homework completion rate, change in physical activity and change in behavior change related measures will be analyzed. Along with socio-demographics I also explore the effects of participants' attitude toward the program. Discovering the effects of adding a game and of applying techniques to encourage participants to complete homework assignments is also important, and therefore, it is worth examining the parameters along the engagement (Non-Contingency, Contingency, Full-Interaction vs. Homework-Only) and adherence (Contingency, Full-Interaction vs. Homework-Only and Non-Contingency) separately. Another important question that remains is whether the Full-Interaction game is a better type of intervention than the Homework-Only intervention, since a game

designer using the DraGuNa framework may be concerned with whether the game developed under this framework will outperform traditional behavior change interventions. Even though no evidence so far supports this particular claim, some evidence may surface through looking at these specific conditions, especially when taking certain confounding factors into consideration. These topics will be addressed in this section. Furthermore, participants' engagement and adherence in the program and their relationship with physical activity gain and change in TTM measures need to be understood.

7.3.1. Gender effects

Since gender has an important role in determining the user's engagement with the program, gender and condition's interaction effect is further tested on the other TTM-related measures, as well as several attitudinal measures and change in participants' physical activity.

Attitudinal measures include participants' liking of the program, honesty during the program and the extent to which participants find the program relaxing. The three questions compose the System Experience Questionnaire, specified below as well as in Appendix D:

How much did you like using the program?

1	2	3	4	5
I disliked it very much	I disliked it somewhat	Neutral	I liked it somewhat	I liked it very much

How likely are you to use the program as a way to relax?

1	2	3	4	5
Extremely unlikely	Unlikely	Neutral	Likely	Extremely likely

How honest do you think you were when reporting your homework progress while you were using the program?

1	2	3	4	5
Extremely dishonest	Dishonest	Neutral	Honest	Extremely honest

First, an ANOVA analysis shows that gender (Male: M=3.87, SD=0.82; Female: M=3.59, SD=0.88) and study condition (HWNL: M=3.80, SD=0.81; NONC: M=3.78, SD=0.85; CONT: M=3.66, SD=1.00; FULL: M=3.75, SD=0.79) have a near significant interaction effect on participants' liking of the program; $F(3,88) = 2.53$, $p<0.1$, $\eta^2 = 0.003$. Also, gender (Male: M=3.53, SD=1.02; Female: M=2.64, SD=1.18) and study condition (HWNL: M=3.32, SD=1.18; NONC: M=3.17, SD=1.11; CONT: M=2.95, SD=1.12; FULL: M=3.12, SD=1.32) have a significant interaction effect on participants' likelihood to use the program as a way to relax; $F(3,88) = 3.62$, $p<0.05$, $\eta^2 = 0.01$. Males in the game-based conditions tend to like the program more and are more likely to use the program to relax than females, whereas females in the Homework-Only condition tend to like the program more than males. The fact that females tend to dislike the game condition has been reflected clearly in the interviews. A few quotes are presented here, and will be discussed in more detail in Section 7.4.

"[I d]id not particularly like it. There were several reasons. One there was a little bit of exercise in it but it was like a story line that wasn't very interesting, and also in cases was not really appropriate and makes assumptions that we're just not okay, making assumptions of a nuclear warfare, and coming up with ideas that I was not comfortable with."

"I think part of the reason that was hard for me to get into the story was because all of the characters were male."

"Maybe including more female characters might help girls relate to it, because a lot of comic books just have guys."

Figures 7.12 and 7.13 illustrate the effects on liking and likelihood to use the program to relax.

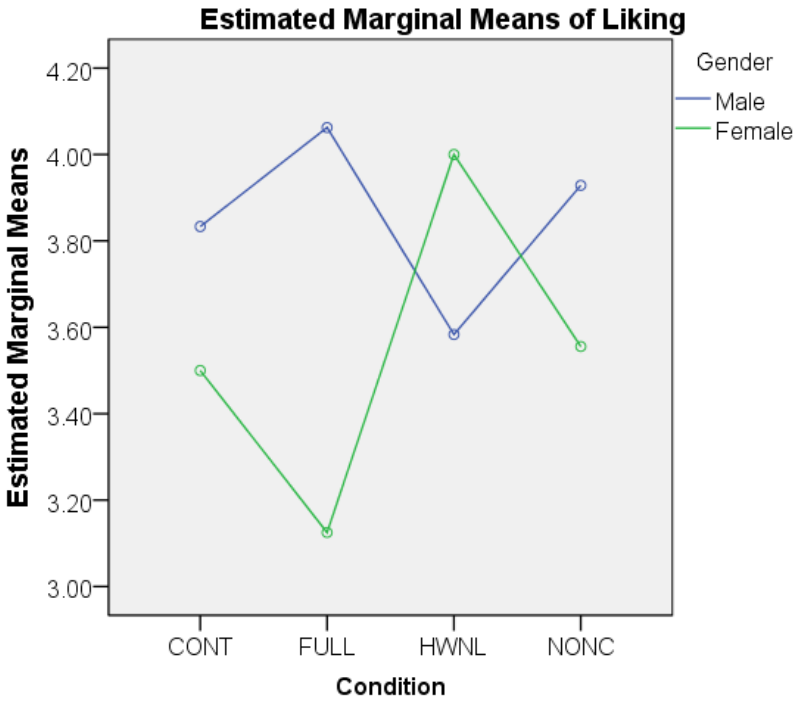

Figure 7.12. Interaction effect of gender and study condition on liking

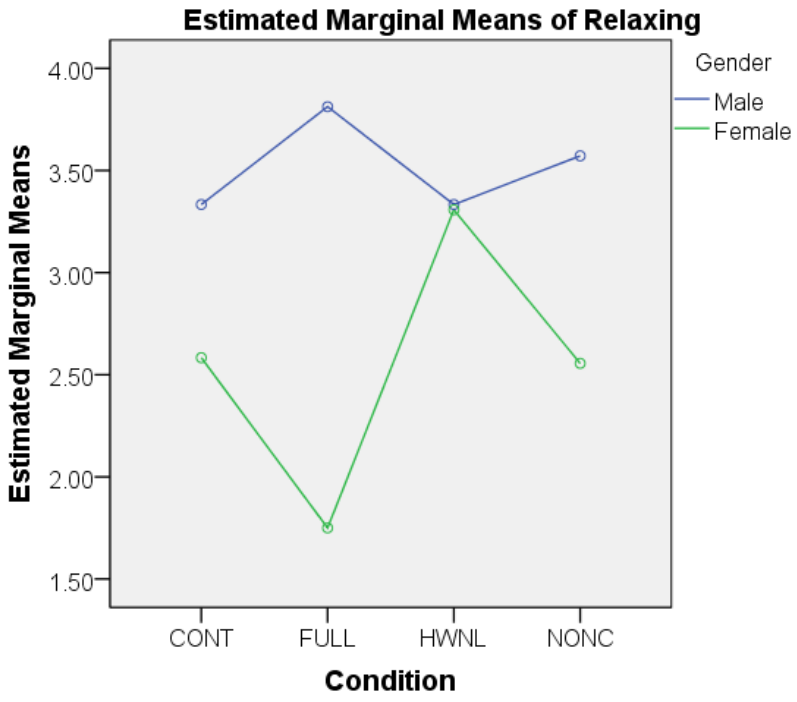

Figure 7.13. Interaction effect of gender and study condition on likelihood to relax

Gender (Male: M=1.81, SD=12.10; Female: M=3.52, SD=11.27), and study condition (HWNL: M=4.40, SD=9.04; NONC: M=3.65, SD=13.13; CONT: M=1.45, SD=11.57; FULL: M=0.70, SD=13.15) also have a significant interaction effect on change in Self-Efficacy among participants; $F(3,88) = 3.20$, $p<0.05$, $\eta^2 = 0.09$, but this effect is complicated. Figure 7.14 illustrates the effect.

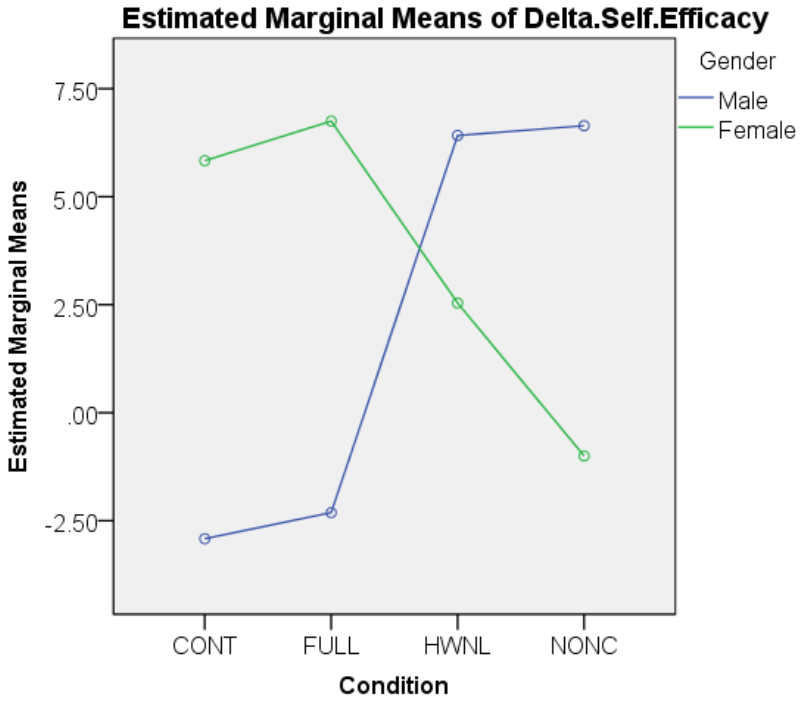

Figure 7.14. Interaction effect of study condition and gender on change in Self-Efficacy

In Contingency and Full-Interaction, female participants experienced more positive change in Self-Efficacy than male participants, even though female participants expressed less liking than males of these conditions, and females also played the game less than males. In Non-Contingency, this effect is reversed: females, who did not like the program as much as males, also experienced less improvements in their Self-Efficacy than males. This is contrary to what can be inferred from participants' liking and usage of the programs. One possible explanation is that the change in Self-Efficacy reflects the genders' reactions to adherence strategies: in Contingency and Full-Interaction, where homework completion is enforced or encouraged, females respond to this enforcement and encouragement better, whereas male participants respond better to Homework-Only and Non-Contingency, where no constraints are laid upon them to complete homework assignments.

However, there is no significant interaction effect between gender and condition on homework completion rate, and therefore this hypothesis is not sufficiently supported. The only conclusion that can be made here is that the effect between gender and study condition on TTM-related outcomes may be more complicated than this study can reveal.

7.3.2 Socio-demographics and attitude toward the program

The interaction effects of socio-demographics and study condition are tested on a few important measures, including total completed sessions, homework completion rate, and change in the participants' physical activity and behavior change related measures. I also included liking of the program and honesty with the program – two self-reported measures – as independent variables. These two measures are included because liking is an important measure that, in addition to total finished sessions, indicates the level of engagement of the participant, while honesty is a potential confounding factor in participants' homework completion rate – some participants who completed all homework might not be very honest with the program.

Although four categories of computer experience were given in the socio-demographics questionnaire, participants only reported to be in two of the categories: "I use one regularly" (n=60) and "I'm an expert" (n=33). The other two options are "I've never used one" and "I've tried one a few times". An ANOVA test reveals a near significant interaction effect of study condition (HWNL: M=4.40, SD=9.04; NONC: M=3.65, SD=13.13; CONT: M=1.45, SD=11.57; FULL: 0.70, SD=13.15) and the participant's self-reported computer experience (Lower experience: M=3.74, SD=11.44; higher experience: M=-0.03, SD=12.07) on change in Self-Efficacy; $F(3,88) = 2.22$, $p<.1$, $\eta^2 = 0.06$. Participants in Contingency and Non-Contingency conditions with higher computer experience seem to experience lower Self-Efficacy gain. Figure 7.15 illustrates this effect.

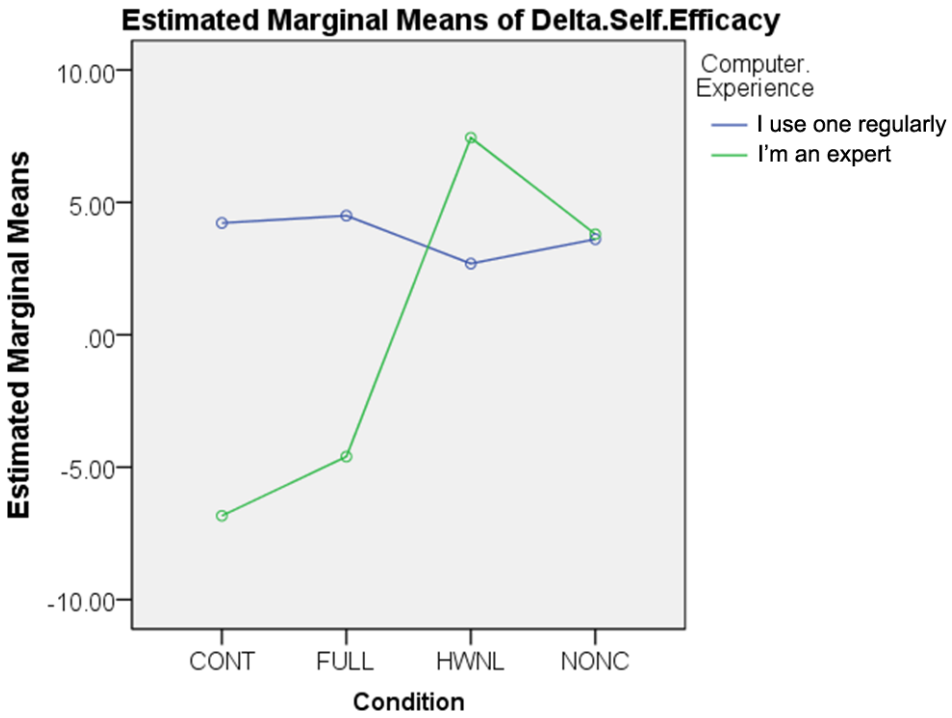

Figure 7.15. Interaction effect of study condition and computer experience on change in Self-Efficacy.

Similar to computer experience, when asked about their feelings towards computers, participants chose between "they can be useful" (n=33) and "I love playing with them" (n=63), even though another two options, "I don't like them" and "they're OK" were also given. A t-test shows that participants who claim that they "love playing with" computers (M=14.92, SD=13.70), compared to those who think computers "can be useful" (M=9.00, SD=13.21), have a significantly more positive change in Processes of Change; $t(94) = 2.03$, $p<.05$, $d = 0.43$. Participants who love computers (M=2.55, SD=4.05) also gained significantly more in terms of Decisional Balance compared to participants who think computers can be useful (M=0.60, SD=4.81); $t(94) = 2.09$, $p<.05$, $d = 0.44$.

The results related to computer experience and computer feeling seem to contradict each other: on the one hand, a higher level of computer experience seems to lead to a lower level of increase in Self-Efficacy among Contingency and Full-Interaction participants; on the other hand, a more positive feeling towards computers seems to lead to better gain in Processes of Change and

Decisional Balance across all four conditions. It is not clear why these effects occurred. To answer these questions requires further investigations.

When asked about their feelings for comic books, participants' answers ranged between "they're OK" (n=20), "they can be good" (n=51) and "I love reading them" (n=25). No participant chose "I don't like them" because these participants were filtered out during the screening process. An ANOVA test reveals a significant interaction effects of study condition (HWNL: M=0.95, SD=0.06, NONC: M=0.88, SD=0.13, CONT: M=0.94, SD=0.11, FULL: M=0.93, SD=0.09) and a participant's feeling towards comic books ("they're OK": M=0.93, SD=0.10, "they can be good": M=0.94, SD=0.09, "I love reading them": M=0.91, SD=0.12) on the participant's homework completion rate; $F(6,84) = 2.71$, $p<.05$, $\eta^2 = 2.36e^{-5}$. Participants who do not like comic books as much seem to complete less homework in the Full-Interaction condition compared to the other conditions, whereas those who like comic books tend to do better in this condition, but worse in the Non-Contingency condition. Simple main effects show that in the Non-Contingency condition, participants who love comic books completed significantly less homework than those not as passionate about comic books; $F(2,84) = 5.26$, $p<.01$. Figure 7.16 illustrates this effect.

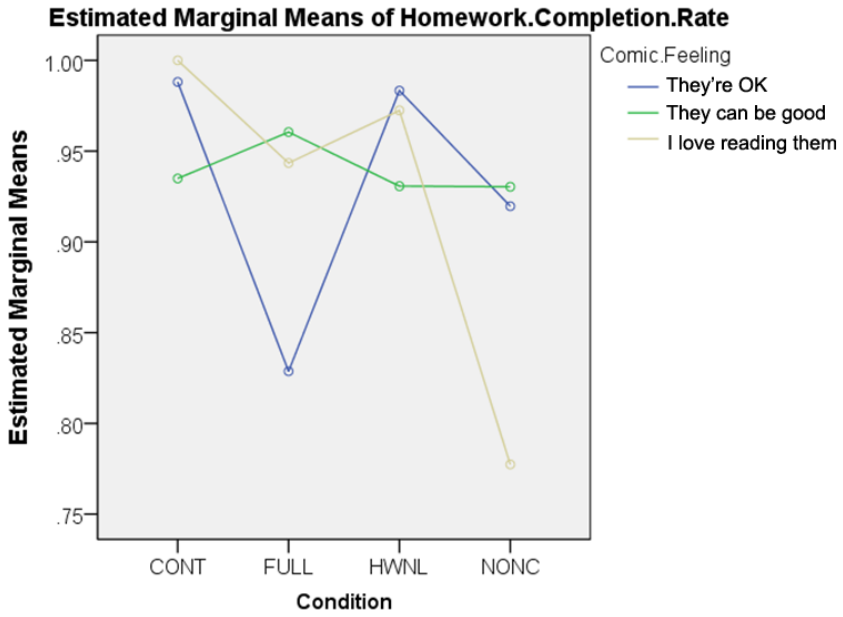

Figure 7.16. Interaction effect of study condition and feeling towards comics on homework completion.

A few more tests were performed to investigate a participant's preferred genres of comic books and their effect on the outcome measures, and upon analyzing both quantitative and qualitative data, understanding the difference between participants who prefer superhero comic books and those who do not seems to be the most important. Through an ANOVA test, a significant interaction effect is found between study condition (HWNL: M=0.95, SD=0.06, NONC: M=0.88, SD=0.13, CONT: M=0.94, SD=0.11, FULL: M=0.93, SD=0.09) and liking of superhero comic books (Like: M=0.92, SD=0.10, Dislike: M=0.93, SD=0.11) on a participant's homework completion rate; $F(3,88) = 3.77$, $p<.05$, $\eta^2 = 0.001$. Change in Stage of Change is also tested for using ANOVA, and for this measure, Pre-Contemplation is coded as 1, whereas Maintenance is coded as 5, with the other Stages of Change in between in ascending order. Therefore, a positive number in change of Stage of Change indicates a participant has advanced from an earlier stage to a later stage. Study condition (HWNL: M=0.72, SD=0.89, NONC: M=0.47, SD=0.51, CONT: M=0.83, SD=0.91, FULL: M=0.75, SD=0.98) and liking of superhero comics (Like: M=0.87, SD=0.94, Dislike: M=0.51, SD=0.68) also have a significant interaction effect on and change in Stage of Change; $F(3,88) = 3.47$, $p<.05$, $\eta^2 = 0.05$. Simple main effects show that in Non-Contingency, participants who favor superhero comic books completed significantly less proportions of homework compared to participants who do not favor superhero comic books; $F(1,88) = 8.22$, $p<.005$, and in the Full-Interaction condition, participants who favor superhero comic books had significantly more positive changes to their Stage of Change throughout the study, as compared to participants who do not favor superhero comic books; $F(1,88) = 13.57$, $p<.001$. Figures 7.17 and 7.18 illustrate these effects. In addition, a near significant interaction effect is also found between study condition (HWNL: M=16.88, SD=9.87, NONC: M=10.52, SD=12.89, CONT: M=12.33, SD=13.09, FULL: M=11.54, SD=18.02) and liking of superhero comics (Like: M=15.04, SD=11.61, Dislike: M=10.63, SD=15.50) on the change in participants' Processes of Change; $F(3,88) = 2.44$, $p<.1$, $\eta^2 = 0.03$. Simple main effects show that participants in the Full-Interaction condition who like superhero comic books gained significantly more improvements in Processes of Change; $F(1,88) = 9.59$, $p<.005$. Figure 7.19 illustrates this effect.

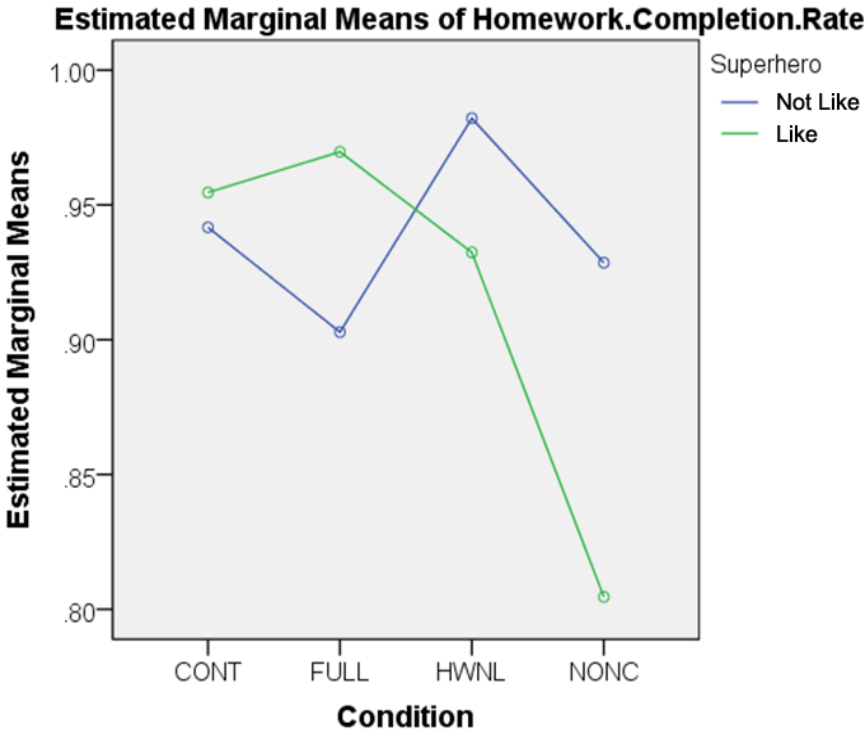

Figure 7.17. Interaction effect of study condition and liking of superhero comic books on homework completion rate.

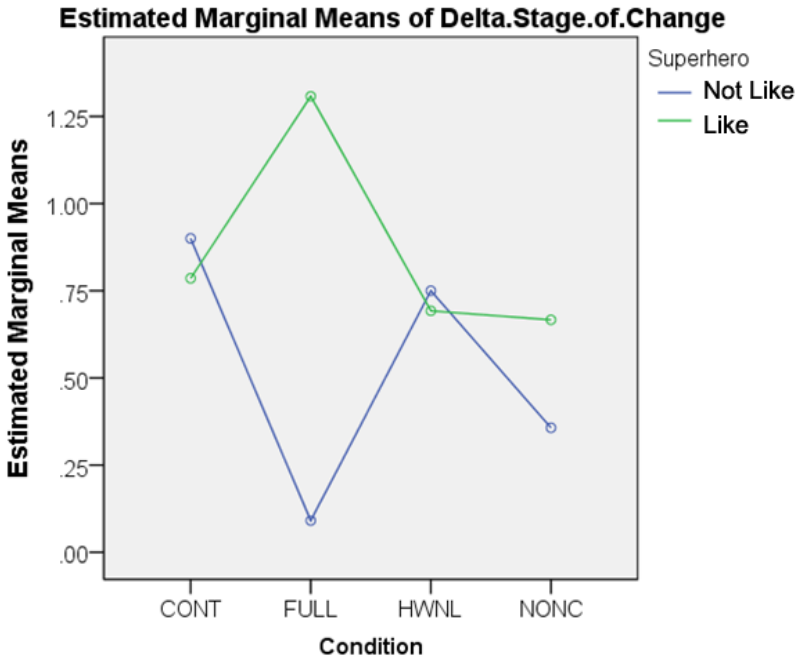

Figure 7.18. Interaction effect of study condition and liking of superhero comic books on change in Stage of Change.

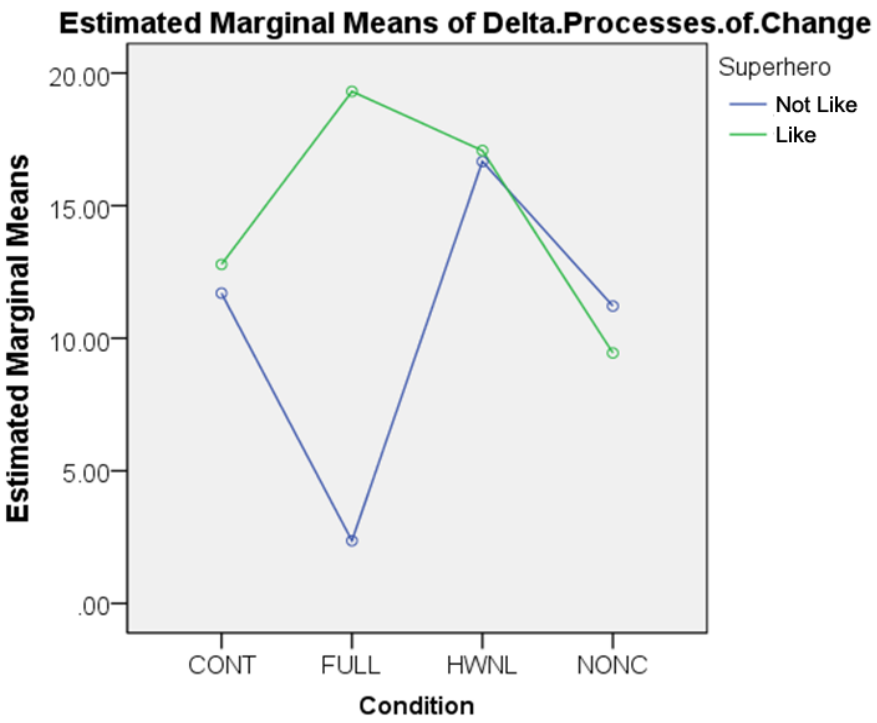

Figure 7.19. Interaction effect of study condition and liking of superhero comic books on change in Processes of Change.

Participants who like comic books and especially superhero comic books seem to do worse in the Non-Contingency condition than their peers. This may be because the setup of the Non-Contingency condition does not provide sufficiently sophisticated structure or a high level of enjoyment to these participants. On the contrary, participants who like superhero comic books gained significantly more in terms of Stage of Change and Processes of Change compared to their peers in the Full-Interaction condition. This seems to imply that even for the population that could potentially enjoy a health game, not just any game would do. Simply meshing together game and behavior change intervention, as I've done in the Non-Contingency condition, can create adverse effects for the target population. If the game is designed properly, as in the Full-Interaction condition, the target audience could potentially gain more. However, another ANOVA also shows that participants in the Contingency (M=3.87, SD=0.67) and Full-Interaction (M=3.79, SD=0.72) conditions are significantly less honest, through self-report, than participants in the Homework-Only (M=4.28, SD=0.54) and Non-Contingency (M=4.30, SD=0.55) conditions; $F(3,92) = 4.31$, $p<.01$, η^2

= 0.003. This means that even if a game encourages participants to complete homework through either negative or positive reinforcement, participants are more likely to lie about their accomplishments. It is also noteworthy that honesty is related to the amount of time a participant spends on each session. The average time spent per session in seconds is positively skewed, with most participants completing an average session within 15 minutes, as shown in Figure 7.20. A regression shows that the average session time significantly predicts honesty, β=0.24, t(94) = 2.40, p<.05, and the average session time explains a significant proportion of variance in honesty, R^2 = 0.05, F(1,94) = 5.79, p < .05. Participants who spend more time on a session tend to be more honest. These participants may be more invested in the program, and may thus hold themselves responsible for completing the homework assignments.

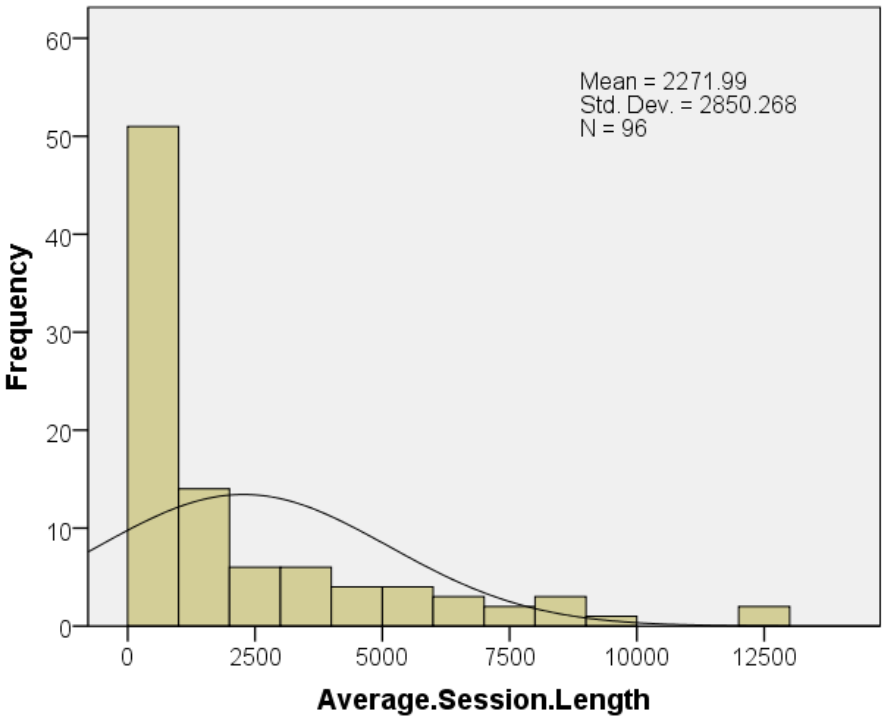

Figure 7.20. Histogram of average session length in seconds.

7.3.3. Comparing Full-Interaction and Homework-Only

The Full-Interaction condition game was created using the DraGuNa framework. One important premise of the experiment is to test how the Full-Interaction condition game compares to the other conditions, in terms of user engagement, adherence to the intervention, and health outcomes,

especially when compared to the Homework-Only condition. A series of analyses are performed on the dataset containing only Homework-Only and Full-Interaction participants, which will be explained in this section. Again, because these analyses do not account for correction for multiple testing, they are less powerful and any conclusions drawn in this section require further scrutiny.

Independent samples t-tests were first performed to compare samples in Homework-Only to those in Full-Interaction on total number of sessions and homework completion rate, as well as on change in Stage of Change, Self-Efficacy, Processes of Change, Decisional Balance, and total physical activity. No significance was found.

When examining gender and study condition, several interaction effects are discovered. An ANOVA analysis shows that gender (Male: M=3.85, SD=0.80; Female: M=3.66, SD=0.79) and study condition (HWNL: M=3.80, SD=0.81; FULL: M=3.75, SD=0.79) have a significant interaction effect on a participant's liking of the program; $F(1,45) = 9.59$, $p<.005$, $\eta^2 = 0.007$. Gender (Male: M=15.17, SD=7.02, Female: M=13.90, SD=6.26) and study condition (HWNL: M=14.72, SD=6.04, FULL: M=14.54, SD=7.40) have a significant interaction effect on total finished sessions; $F(1,45) = 7.86$, $p<.01$, $\eta^2 = 0.02$. Gender (Male: M=1.42, SD=10.96; Female: M=4.14, SD=11.78) and study condition (HWNL: M=4.40, SD=9.04; FULL: M=0.70, SD=13.15) also have a near significant interaction effect on change in Sefl-Efficacy; $F(1,45) = 4.00$, $p<.1$, $\eta^2 = 0.07$. These effects are generally in favor of male participants in the Full-Interaction condition, and in favor of females in the Homework-Only condition, except for change in Self-Efficacy. This is consistent with our findings in Section 7.3.1. Figures 7.21 through 7.23 illustrate these effects.

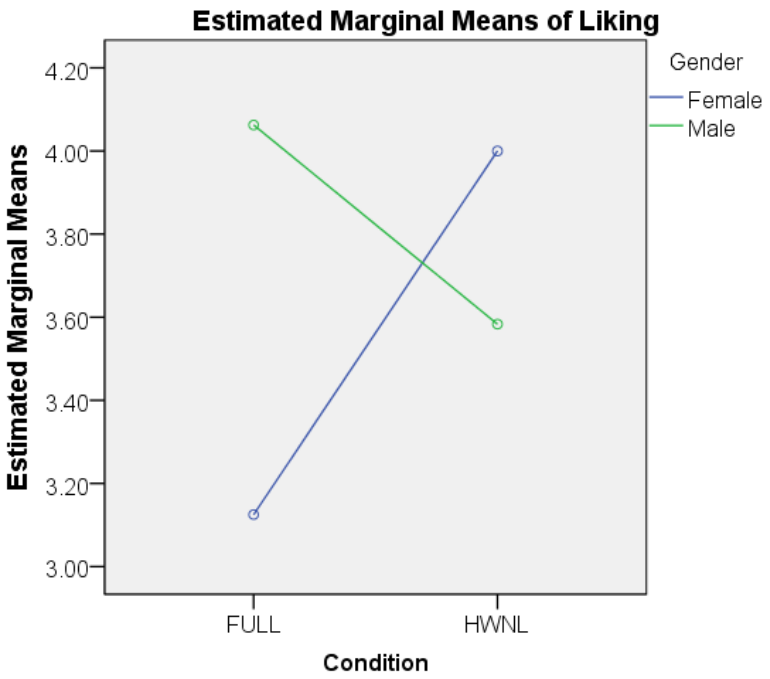

Figure 7.21. Interaction effect of study condition (Full-Interaction and Homework-Only) and gender on liking of the program.

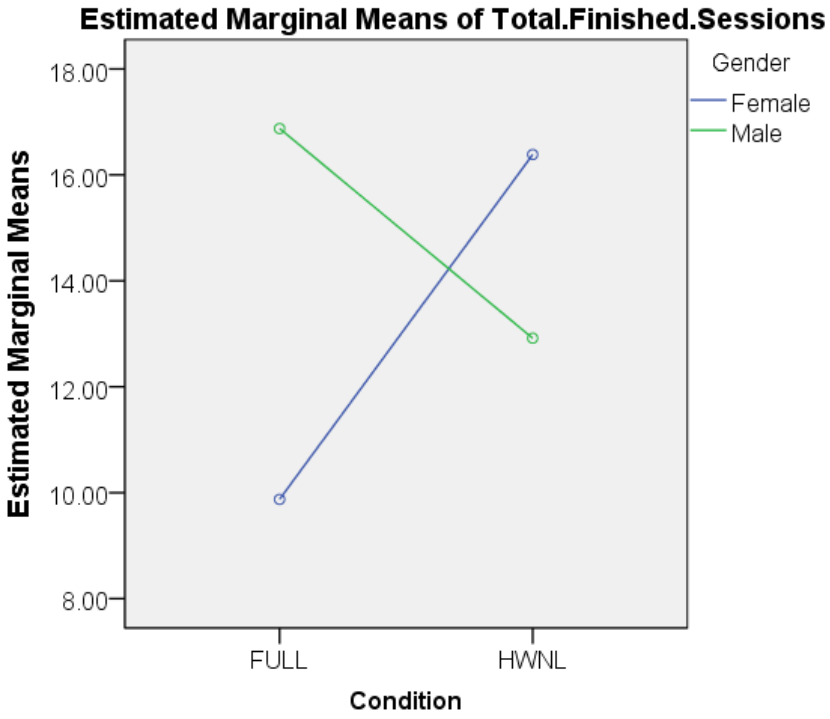

Figure 7.22. Interaction effect of study condition (Full-Interaction and Homework-Only) and gender on total finished sessions.

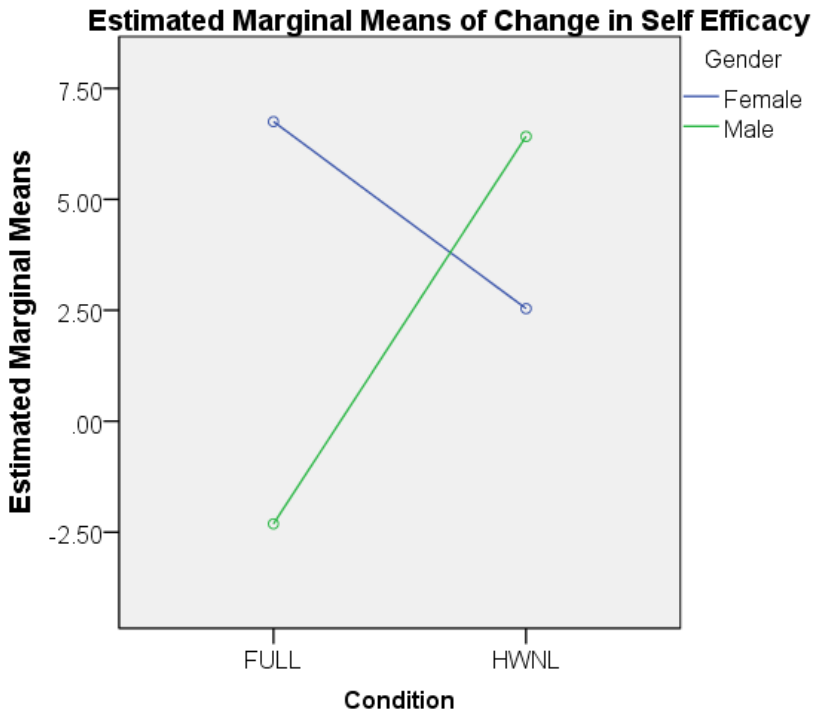

Figure 7.23. Interaction effect of study condition (Full-Interaction and Homework-Only) and gender on change in Self-Efficacy.

ANOVA tests performed on study condition and liking of superhero comic books found significant interaction effects of the two factors on several dependent variables. First, study condition (HWNL: M=0.95, SD=0.06; FULL: M=0.93, SD=0.09) and liking of superhero comics (Like: M=0.95, SD=0.06; Dislike: M=0.94, SD=0.10) have a significant interaction effect on homework completion rate; $F(1,45) = 6.60$, $p<.05$, $\eta^2 = 0.0009$. Second, study condition (HWNL: M=0.72, SD=0.89; FULL: M=0.75, SD=0.98) and liking of superhero comics (Like: M=1.00, SD=1.01; Dislike: M=0.43, SD=0.72) have a significant interaction effect on change in Stage of Change; $F(1,45) = 6.81$, $p<.05$, $\eta^2 = 0.07$. Finally, study condition (HWNL: M=16.88, SD=9.87; FULL: M=11.54, SD=18.02) and liking of superhero comics (Like: M=18.19, SD=11.90; Dislike: M=9.82, SD=16.18) also have a significant interaction effect on change in Processes of Change; $F(1,45) = 4.62$, $p<.05$, $\eta^2 = 0.04$. Participants in the Full-Interaction condition who like superhero comic books had more proportions of homework assignments completed, and experienced more improvements in their Stage of Change and Processes of Change, as compared to those who did not express a particular liking of superhero comic books. Figures 7.24 through 7.26 illustrate these effects.

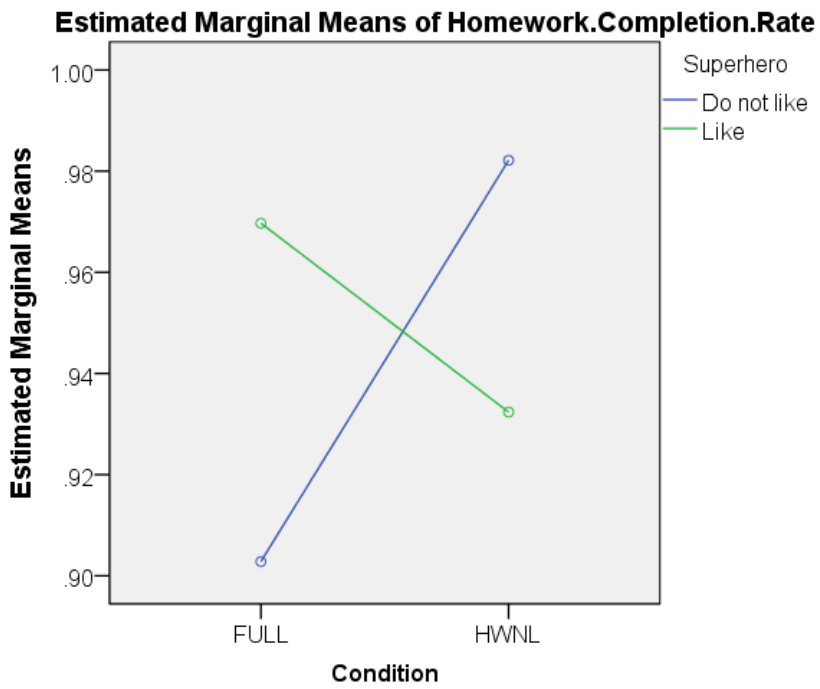

Figure 7.24. Interaction effect of study condition (Full-Interaction and Homework-Only) and liking of superhero comic books on homework completion rate.

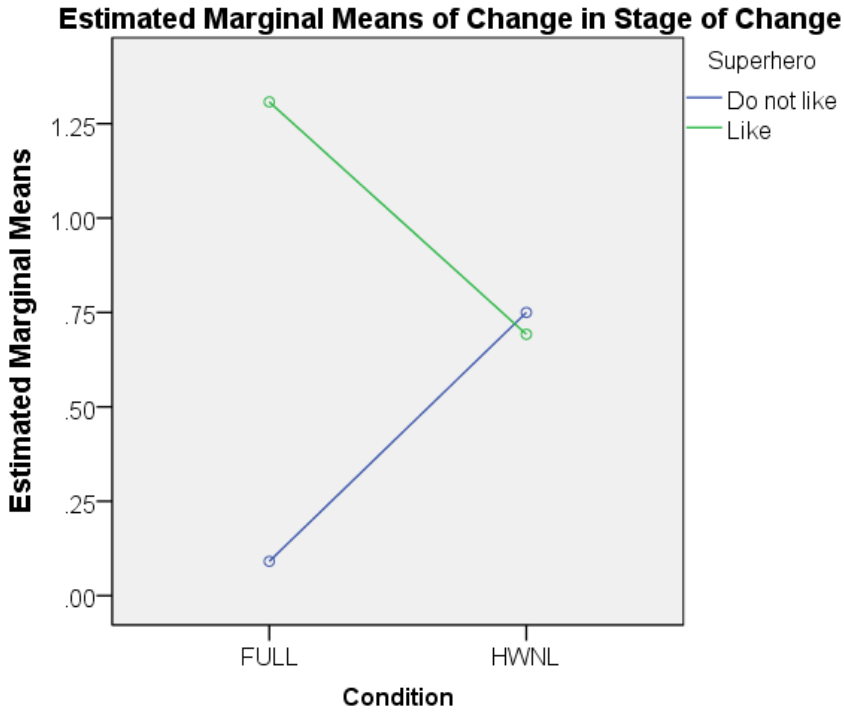

Figure 7.25. Interaction effect of study condition (Full-Interaction and Homework-Only) and liking of superhero comic books on change in Stage of Change.

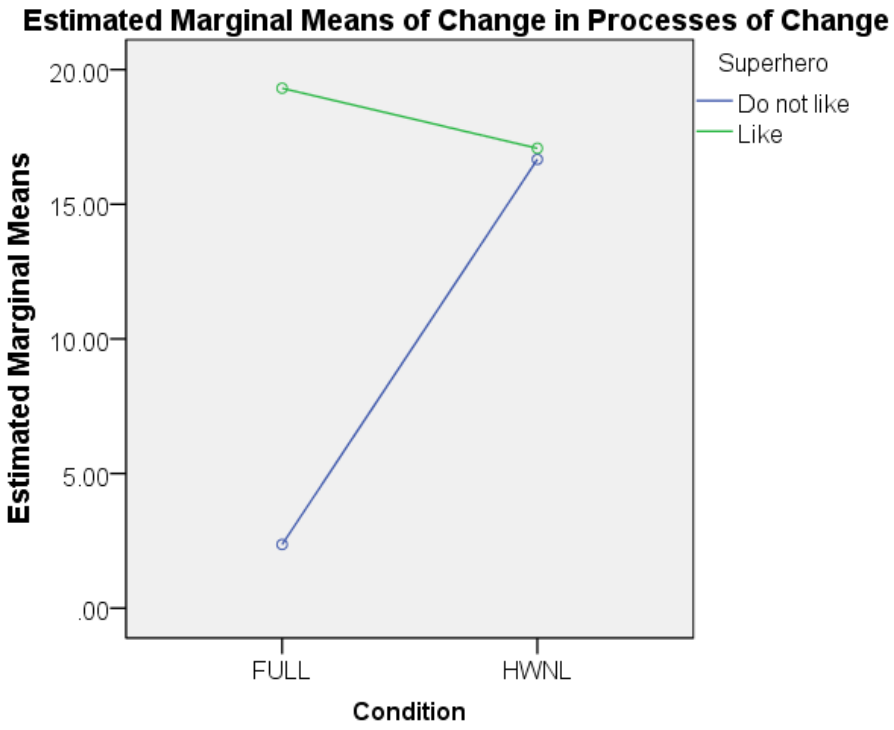

Figure 7.26. Interaction effect of study condition (Full-Interaction and Homework-Only) and liking of superhero comic books on change in Processes of Change.

Overall, males and users who enjoy superhero comic books seem to enjoy the Full-Interaction game more than others, complete more homework, and have more positive health gains. This is an important message for designers of health games: when designing games for health, understanding of the target population may be of utmost important for the design of a game effective in promoting behavior change, and for participants who may not enjoy the game, it may be best to give them alternative interventions.

7.4. Qualitative Results

Interview recordings of participants at the debriefing session are transcribed and coded. Questions for the semi-structured interview can be found in Appendix E. Based on the questions and the range of topics covered by participants' responses, the coding manual is divided into different sections: general, issues, life impact, future usage, story, connection between story and exercise, exercise, homework, motivation, memorable moments, art & music, and contingency. In this section,

each topic will be explained and the participants' responses related to each area will be discussed. After each participant's ID, the participant's gender and study condition will also be specified.

7.4.1. Enjoyment

Overall, the vast majority of participants expressed a liking of the program. Only two participants expressed clear disliking of the program, one in the Contingency condition, who felt the program was "a waste of time", and one in the Full-Interaction condition, who did not like the "assumptions of a nuclear warfare" depicted in the story, as has already been briefly discussed in Section 7.3.1. A few participants' comments are quoted below.

"The program was interesting. It doesn't ask you to do something out of your way. It's something that anyone can manage in a day's time. Like it asks you to take a walk instead of watching TV. It's a very doable thing you can say. It really helps. If someone does follow the program properly, it will help you in exercising, or probably getting into exercise, normally and every day regularly."

-- Participant 31, Female, HWNL

"I think I was able to enjoy it because the art style was not focused on being the three dimensional real sort of thing. It was just comics. It was easier to enjoy."

-- Participant 9, Male, NONC

"I haven't come across any such kind of program, so it was quite interesting. When I was stressed out and I have to do it every day, I would take a break and take this."

-- Participant 92, Male, CONT

"What has attracted me the most is the history of the main character, which is me … what has happened to him, and why did he lose all his memory, and how did he save the life of Bill Tyler. In the end of the program, I knew that he is a person with the power of atomic energy, and he saved the whole America and all American people."

-- Participant 73, Male, FULL

"[I d]id not particularly like it. There were several reasons. One there was a little bit of exercise in it but it was like a story line that wasn't very interesting, and also in cases was not really appropriate and makes assumptions that we're just not okay, making assumptions of a nuclear warfare, and coming up with ideas that I was not comfortable with."

-- Participant 35, Female, FULL

Delving deeper into some of the female participants' comments, I noticed that several female participants did not find the comic book story appealing because the story simply wasn't designed for the female audience due to its historical limitations. I also noticed that several male participants in the Homework-Only condition, although they did not dislike the program, expressed that they expected something more interactive and engaging.

"I think part of the reason that was hard for me to get into the story was because all of the characters were male."

-- Participant 30, Female, NONC

"Maybe including more female characters might help girls relate to it, because a lot of comic books just have guys."

-- Participant 95, Female, CONT

"The tasks it gave me wasn't that exciting and I felt that it didn't engage me as many other programs that are on the market. Not that I'm an expert what's on the market, but it seems like a very simple bare-bones system, which utilitarian purposes it's okay but… I understand it's trying to get me to… there are so many benefits of exercise. Having researched that I totally agree with that, but it wasn't my favorite thing to use."

-- Participant 74, Male, HWNL

A few participants mentioned that the program was educational and well-paced, but participants also complained about several common issues: some participants complained that the text was too

small, which could have been solved by switching the program to full-screen mode, but since this was only demonstrated once in the intake and wasn't written in an instruction file, many participants appeared ignorant of the function; some participants suggested that the game could use some voice acting; and some also complained that typing in the homework report was too much work. A participant in the Homework-Only condition complained that the interface was too bland, as seen in the following quote.

"[T]he program just did not work well a lot of the time, didn't save well. A lot of times I completed a session and it says it was completed and I go back the next day and I have to do it again."

-- Participant 35, Female, FULL

"It had a very bland interface, and I think that may have contributed to [me not using it more often] a little bit. I feel like if there was just even just something little, like every day it was a little helpful tip, a picture or something, and then I would at least have something to look forward to."

-- Participant 51, Male, HWNL

7.4.2. Usage Patterns

Regarding the usage of the program, some participants, mostly students, explained that sometimes they would forget to use it, or become too busy to use it because of their school work. A few participants also said that there were occasions where their computer was not available and having a mobile alternative to check in and report their progress would be a good additional function. Quite a few participants also mentioned that the pattern of usage was not always steady: some participants did not have much interest in the program in the beginning, but gained interest or became more habitual at using the program over time; while others were excited about the program in the beginning, yet lost interest or became more occupied and thus had to reduce their frequency of program usage over time.

"I used the program every day I think the first week I kind of tripped up and kept forgetting to use it. But then I put it on my to-do list and used it every single day."

-- Participant 93, Female, HWNL

"Initially [I used it] regularly. But then as time went on, there were mid-terms and assignments so went on 2 or 3 times a week.

-- Participant 36, Male, CONT

A few participants complained that the session was too long, and some explained that they skipped some of the content. On the other hand, some participants elaborated that they enjoyed the sessions because they were not too long. A few participants also said the sessions were too frequent and that they preferred less frequent, but longer game sessions. In a participant's own words, he preferred to "complete the comic in one go".

"I mean I like reading comic sometimes. I feel like if each one was shorter then I would be fine with it…"

-- Participant 72, Female, NONC

"I realized it took such a short amount of time to complete a part of it, I was able to do it every morning before class, so if I had a class at 9AM, it wasn't a problem to do the session, have the homework, go to class, come back and be able to complete the homework during the afternoon or evening, so that I could report to it back in the morning."

-- Participant 44, Female, NONC

Participants who feel that playing the game is a way of relaxation do not necessarily achieve better behavior change: some participants found the game relaxing, but others found the entire setup of the study serious rather than relaxing. The following quotes explain this diversion.

"It was a good program because I tried to find many things about doing exercise and what I benefit from exercising by doing homework. I was able to recall many cartoon characters which was asked in the program, how many of them can benefit from exercising, I was able to relate them. It was good. The comic was also good. It was relaxing when watching it."

-- Participant 32, Male, CONT

"For me I'd just try to start exercising. I would use [the game] more as a way to get me to exercise rather than to play the game and relax."

-- Participant 46, Female, FULL

For some participants, the program is a shared experience with their significant other or close friends. The shared experience ranges from discussing homework assignments together to one person reading the comic book to another, as shown in the following quote. This is a pattern unintended in the design of the game but may be important to explore in the future.

"So [my boyfriend] and I would be looking at the screen, and he would pretend he was the different voices. He was reading the story line. Sometimes I would switch in and he would go do something and I would read to him. So we were both participating at the same time."

-- Participant 66, Female, FULL

7.4.3. Issues

Participants reported several usage issues during the interview, the most common ones related to the scheduled usage of the system. One particular issue that happened to multiple participants is repeated sessions: when a participant reaches the last scene of a game session, where the screen prints out "Left click on the screen to end the session", instead of left clicking on the screen, which triggers a "game end" command on the server, a few participants closed the window directly, which would cause a forced disconnection from the server. Because the user's session is only registered after the user has completed the entire session, i.e. when the "game end" command is triggered, closing the window causes the server to believe the user has not completed the current session. On the next day, when the user logs in again, the previous session will be given to the user again, causing frustration. Another related issue is that some participants would use the program past midnight, thinking that it would still count as the day before, and when they try to use the program again on the same day, they would find that they could not play another session. A possible solution

is to make the program's schedule more flexible, so that users can choose to play a number of sessions on one day, which would seem to fit a lot of users' desired usage pattern.

Some participants complained about interface issues, including when typing in their answers to a previous homework assignment there is no easy way of deleting multiple words except pushing backspace all the way back, the text sometimes does not completely fit in the bubble, then sometimes the bubbles are way too big, and occasionally a typo would appear in a text bubble or narrator text. Participants explained that they sometimes flipped through a page too fast, and although the program could roll back to a previous frame on the same page of the comic book, it could not roll back to a previous page, which sometimes became annoying. A few participants also suggested that a spellchecker be implemented to help them typing in the answers to their homework.

A few participants complained that the program sometimes failed to connect to the server. This is believed to be because of the quality of the campus internet and not due to the program itself. Following are a few quotes about these issues.

"If I would go in again later it would have been fine. So I might not have clicked through all the way or… Also I noticed that one of the improvements that could be made was that as soon as you start typing your answer, the question disappears, and I was like I forgot what it was."

-- Participant 89, Female, HWNL

"It was difficult to read at times because of the lag in the program and the way the words pop up, and they didn't mesh with the comic. That was frustrating."

-- Participant 76, Female, CONT

7.4.4. Story

Most participants in the Non-Contingency, Contingency and Full-Interaction conditions found the story interesting. Those who found the story interesting tend to be engaged to the game's Sci-Fi

appeal and historical appeal, or they felt the story was funny, while those who found the story to be not appealing thought the story to be too old, poorly-organized or not their preferred genre.

"The concept of the atomic commandos was interesting enough, just elite core group of soldiers fighting aliens, other races on Earth, Soviets. So that kept my interest a lot. I like that kind of thing especially Cold War era, technology, fighting, mixed with a bit of sci-fi, so that was interesting."

-- Participant 70, Male, CONT

"They're old fashion comics. By today's standards… it was four-color print, the visual could be different but I do like the old style comic, so I like it. I like the story too. I like the sci-fi, whole golden-age nuclear war, aliens coming down. It's good."

-- Participant 11, Female, CONT

A few participants commented that the story was "strange" or "confusing", and this sometimes affected their perception of the story and of the program. The following quote is from a participant in the Non-Contingency condition. Participants do not feel the confusion due to the same reason, but it is likely that the confusion comes partially from the story itself being from an older time and not structured to the taste of today's audience, and partially from the disconnection between the story and the player character's role in the story in the Non-Contingency and Contingency conditions.

"I didn't know how I would fit in to the story. Because I know every once in a while it would make references to me, but it was confusing how I would fit in to the story. Other than that I thought the story was really nice. I don't think it was necessary for me to be part of the story."

-- Participant 21, Female, CONT

7.4.5. Exercise

Regarding the effect of the program on the participants' exercise behavior, a large number of participants mentioned that the program raised their awareness of physical activity, and a few participants said they exercised more, or specifically walked more. Several participants were

somewhere in between, some were trying to work out more, others claimed that they would do more in the future, yet others felt bad for not exercising. A few participants were clear that although they might have liked the program, they were not working out more. Some participants also said that even though they were not working out regularly, the program did give them a push to start exercising.

"Last week, I exercised every day. I think if you go do it every day, you get the thought in your head that I need to exercise, which I'm sure is the point. So once my midterms were done, I just realized that I do have time, then I didn't but then with normal classes, I knew I had time to do it, half an hour every day."

-- Participant 46, Female, FULL

"It did motivate me. Gave me a little push to do more. ... I walked a lot more than I did a month before. ... I use the Green B Line because I live next to BU. These trollies are always crowded. Sometimes you can't even get in especially in the morning time. A couple of times a couple of trollies came and they were full so I said forget it. So I just walked. It put something in your head: you have other options. You can walk."

-- Participant 4, Male, CONT

"I feel like the program did a good job in getting me to actually look into exercise and become more active and it forced me to do those things that I wouldn't have normally done, and if I missed a day I would panic, because I wanted to get through as much as I could, but I also felt the program was very enjoyable in itself."

-- Participant 51, Male, HWNL

"I think right now I got a different point of view on exercising. I check my local gyms. Plus I downloaded an app for 100 push-ups. I tried to do it two days and I gave up. But anyways some small progress."

-- Participant 16, Male, NONC

Several participants, by performing the homework assignments suggested by the program, saw an opportunity to start working out with their friends. The following quote is from a participant in the Contingency condition.

"I went to the YMCA with my friends. They told me how to do those motions. It was weird for me at first, but then I went there a few times, I got better, and it seemed easy. I got fluent, and just got through the motion a few days later. They usually went but I never went. But then I thought it would be a nice chance to try it out, and it also fulfilled the assignment."

-- Participant 7

7.4.6. Homework

When asked about how they feel about the homework assignments, participants had a variety of responses: some claimed they had no problems with the homework, and some felt that the homework assignments related to them in a personal way, while others felt the homework assignments sometimes were boring, or repetitive (a few homework assignments are worded similarly but focused on different aspects of the benefits of exercising). Still a few participants felt some homework assignments made them uncomfortable, even though they are recommended in a typical behavior change intervention.

"I thought that there were some questions which were repetitive, there were some questions which definitely did encourage me to exercise, and there were some that definitely did not. Questions asking about the healthcare system, positive effects of exercise, I thought those were good. Questions asking about a TV character who exercises, I didn't feel were quite relevant and didn't provide as much motivation."

-- Participant 68, Male, HWNL

"I felt like the exercise questions were a little repetitive. There was one that's about a TV show, think about a character in a TV show who might benefit from exercise, and there's another question that is think of a character that looks like they're benefiting from exercise. I don't watch a lot of TV so it's hard to think of something."

-- Participant 15, Female, CONT

"I thought a lot of the questions about asking about family members or friends to talk about benefits of exercise, I felt like with those questions it was asking me to judge them in some way, which I didn't really feel comfortable doing, because I figured that other people's health was their business. I mean everyone I've talked to knows exercise is beneficial for them, but they often have their own reasons for not exercising, so I didn't really like those homework assignments that ask about other people. I think for every person it's individual. For some people it might be helpful to look at other people, but it made me feel weird to do that."

-- Participant 95, Female, CONT

Several participants suggested that having homework assignments that require them to actually do exercise, instead of merely raising their awareness of exercising, may be more beneficial. This is because all the participants were in Pre-Contemplation, Contemplation and Preparation stages of change, and although the Preparation stage participants may have received a few homework assignments that are action oriented, the majority of participants were give assignments focused on raising their awareness and getting prepared for physical activity.

"I don't know if it continues on to this and I haven't reached it yet, but I'd like to see it actually have me do something instead of just look up the info … I'd like to see further along in the game your homework assignment is to take a 15 minute walk around your neighborhood or take a different walking route to get to your train station. Just to vary it. And have that be your homework assignment, not just a reading assignment or thinking about assignment."

-- Participant 11, Female, CONT

A few participants also felt that more feedback on how they performed on the homework assignments would benefit them, but they understood that it was difficult to do with an automated program, as implied in the following quote.

"…if you're reporting back to somebody, and they can't directly say what you're thinking. Like if you say I've decided I'm going to work out with Sally every Friday, they can't say oh I'm glad to hear Sally. There's that small disconnect, but that's so hard. I don't know how you can do that."

-- Participant 66, Female, FULL

Participants in the game-based conditions were also asked what they would do differently if they were to use a program without the interactive comic book, essentially putting them in a situation identical to those in the Homework-Only condition, the majority of participants expressed a concern that having only homework assignments would not be enough to motivate them, while a few participant felt that the interactive comic book wasn't necessary, but they also expressed that having homework assignments without the game elements would make them feel more obligated to complete it, rather than using it as a means to relax.

"I think I'd prefer the homework because it's more straight to the point, rather than having a particular comic topic and then jumping on something completely different. That's just kind of abstract, the other way around. If the comic book wasn't there, it would seem like a less informal program, a much more formal program, … like school work or work. Yes I would feel more obligated to do it."

-- Participant 103, Male, FULL

"I felt like it would have been less interesting [without the comic book]. Part of me, why I would do the program was just… it wasn't even exercise. I actually like reading the comic book, so for me I would be more likely to go on the program if there was the comic in there."

-- Participant 83, Male, NONC

"That probably would work but still you will need something like when you go to school, they teach you the lecture and after that they give you the homework, so you need something before you're given the homework, in this case it's the story. So perhaps a story, or a little video, a little article

about exercise, something like that, wouldn't be really long like the video game, the story, like 5, 10, 20 minutes of video."

-- Participant 4, Male, CONT

7.4.7. Connection between Story and Exercise

When asked whether a connection exists between the story in the game and physical activity, participants gave interesting and sometimes unexpected responses. A number of participants in the Non-Contingency condition felt that there was no connection between the story and physical activity, as implied in the following quote. The much smaller number of participants in Contingency and Full-Interaction felt this way.

"The story didn't really relate to what I figured was the goal of the program: exercise. Maybe if the story related to that more, so the homework would have more to do with the story, that would make it less disjoined."

-- Participant 30, Female, NONC

Two participants in the Contingency condition and one participant in the Non-Contingency condition explained that they felt there was a connection between the story and exercising, but the connection is not intended in the program, as indicated by the following quote.

"The atomic commandos, they all had different specialties I guess, but then they were all different. They were physical, some of them used their brain a lot, and some of them were just really smart. I think those should be all the qualities that somebody can work on when they try to exercise to, like they can get stronger, they can clear their mind, and then they can think better. Stuff like that."

-- Participant 114, Female, CONT

Eight of the twenty-four participants who were interviewed in the Full-Interaction condition expressed they understood the connection between the story and exercising as intended by the game, meaning that they understood the player had to exercise to help with the missions, and that non-player characters would react more positively if they completed the missions, as suggested by

the following quote. A large number of participants in the Full-Interaction condition also expressed that they not only recognized the mechanics used to encourage them to complete more missions, but they also liked the reward.

"Yes it responded to me in a positive way. And after I completed what I've found, in the mission, in the middle of the session, some character will reveal himself to me, and in that way I will know more about him. And besides I thought that his impression on me became better that way, and I guessed it would influence the way the game goes, and even may have an effect on the ending."

-- Participant 73, Male, FULL

"Yeah [when I complete homework] everything is a lot more positive. It was easier to get stories from the different characters and to get them to tell me things, and to get them to start telling me things about myself. It was definitely a good way to do it, because if completing the missions gets you a better story line and more likely to succeed in the story, it's not positive reinforcement? Well I guess it is. It just made it feel better because if I was doing what I was supposed to, the story was progressing in a way that was much more likely to wind up in success."

-- Participant 43, Female, FULL

"[When I did not complete my homework] they said they were really disappointed. I felt more than I thought I would because they kept saying 'oh that really stinks that you didn't do it' and they kept saying it throughout, so it made me feel like 'oh now I feel like I really let them down'. It just felt like more of a connection than just a computer game like "oh no you didn't do it"."

-- Participant 46, Female, FULL

Because the ending of the Full-Interaction game is connected to the player character's story, participants in the Full-Interaction condition were asked what they thought about the ending. Four participants elaborated on this question, some of which stated that they liked the ending because it is closely tied to the story and the player character's story arc, and some also complained that the final battle could have been depicted with more detail and style (because the ending was an

addition to the original story and the frames were composed by reusing several frames from the original comic book), as implied by the following quotes.

"Yeah. The ending was really nice, that again he goes to sleep and once he wakes up there's a picture of the Boston city. That was really cool."

-- Participant 57, Male, FULL

"Actually the last session is very amazing. … You know I actually expected more detailed information about that because this is the climax of the whole program. I like it but it can be better. It can describe the emotion of [my character], the reaction of all the other commanders. It could give more detailed information about the very moment of the final battle."

-- Participant 73, Male, FULL

There also appears to be a difference between male and female participants in the way they discussed the fact that the story came from an old-style comic books. Male participants tend to have a more positive response to this story choice, while female participants, although they don't dislike the story, don't seem to be very excited about it either. The following quotes show some of these responses.

"There's some interesting little stories, so it's interesting to see how the commandos get out of all those little tricky situations. So it was fun. It was nice. The story was fun in the sense that it was like an old-style comic, which was nice."

-- Participant 21, Female, CONT

"I knew this was supposed to be science fiction, but there were different genres of science fiction, and once I realized now I know what kind of genre it is I had more fun with it. …The moment was that oh that's funny, how do they do that? When I realize it wasn't hard science fiction, trying to be historical and physically accurate. Once you let go of that limitation, you can have fun with the story. The moment when the story was unbelievable was when I enjoyed it, to see where it's going."

-- Participant 9, Male, NONC

This difference may shed some light on why male and female participants experienced significantly different gains in their physical activity and behavior change measures after playing the game. Specifically, comic book experience and feelings toward comic books did not make much of a difference in the participants' reception of the game and in their behavior change, but the participant's gender did. This may be because male participants are more predisposed to be more accepting of Golden Age comics, thus they are more receptive of a game made out of a Golden Age comic book; female participants, on the other hand, may enjoy comic books in general, but may not have a specific preference of Golden Age comic books, and Cold War hero stories in particular. These comments also brought up the subtle details related to the story and the potential impact they can make. Specifically, Participant 9 mentioned there are many sub-genres of science fiction, and even though he generally liked science fiction, the story still initially threw him off. Many other subtleties may have had similar effects, such as an all-male cast, the 1950s vocabulary and conversation style, the retro art style, and the fact that, unlike in modern sci-fi, the inventions in the story were created with no scientific explanation whatsoever, etc. These factors could all have caused individuals to like or dislike the game, and they could also have partially caused the gender difference in liking of and engagement with the program. These differences in preferences should be noted for games for health designers: if a game designer were to create a game from a pool of existing stories, the designer may be limited to what the pool of stories has to offer, which can 1) restrict the designer in terms of the stories' genre and time of creation, and 2) yield undesired results in the target audience. The availability of stories in a game designer's command can heavily affect the reaction to the story from different audiences, which may restrict the game designer's choice of target audience. A game designer who chooses to create an original story, on the other hand, has a higher degree of freedom from these issues.

7.4.8. Motivation

Participants had different motivations to use the program. Most participants expressed a feeling of obligation due to their commitment to participating in the study, but several participants also

explained that they wanted to continue using the program because they were concerned about their own physical health, their family's health, or their fitness. A few quotes below demonstrate these concerns.

"I'm 41 years old and I'm not in the shape I used to be. I used to have a lot more time to exercise. I have a lot more stress. I have a lot more other commitments that came in to fill up my time, but my physical abilities: A, are deteriorating because I'm older; but B, because I don't use them enough. There's heart disease in my family and I don't want to have a heart attack and die. Many motivations. Healthier is better."

-- Participant 74, Male, HWNL

"I really wanted to avoid Freshman 15. … So I'm like I can't get Freshman 15. I need to stay the way I came in. I just needed the push."

-- Participant 38, Female, HWNL

"The ones that reminded me about family and health. I told you the ones that told you to think about a family member who could benefit from exercising, considering this last month involves my father's failing health and an ongoing struggle I have with him to take walks that he's supposed to. His doctor's told him he has congest part failure and other diabetes and a number of other health issues. He's supposed to take a short walk every day and he doesn't. We have an ongoing thing where I purposefully forget something at the grocery store just to be like "I have to go to work and you have to go to the corner store to get it". I had to trick him into exercising. That struck home. That was more of a motivation that got me thinking than anything else in the program. It happened concurrently."

-- Participant 10, Female, CONT

As participants started using the program, some of them became curious about the future homework assignments they were going to get, some in the game-based conditions became curious about what would happen in the story, and a few were curious about the health outcomes

that they would gain at the end of the study. Particularly, participants in the Full-Interaction condition expressed that an interest in revealing the player character's lost memories served as a motivation to continue using the program, as per the following quote.

"[I played the game] just to see where the story went."

-- Participant 21, Female, CONT

"Because I always wanted to know what is next that is coming up for me, exercising in a new way, or what benefit it would give me I was very eager to know: how would it really provoke me to go and exercise regularly."

-- Participant 33, Female, NONC

"Mostly that I wanted to complete it as much as I could and see if it had a real tangible impact on my desire to exercise, because I'm really excited to see if there's some magic to make me exercise more, so I just wanted to keep going through with it."

-- Participant 111, Male, FULL

"I want to find out the rest of the information about the guy I was revealing pieces of. It would be like every time I did something, "you revealed a piece!" So I want to finish doing that."

-- Participant 91, Female, FULL

Still, a few participants indicated that their motivation came from the satisfaction of achievement as they completed each homework assignment, and the fact that some of the homework assignments asked them to socialize with people, which served as a medium to reach out to their social connections.

"While I was at it the program gave me homework so to find the solution sometimes I had to go Google it. The answer I got already changed my outlook. It made me [realize] how important exercise is. That gave me motivation. Knowing the benefits, I got interested."

-- Participant 62

7.4.9. Memorable Moments

As a way of measuring participants' engagement with the program, participants were asked to recall one or two memorable moments from the program. Over half of the participants across all conditions managed to recall some specific details of the story. When analyzing the responses to this question, about an equal number of participants recalled some details of a homework assignments and recalled some details of the story.

"The one part of the comic that I really remembered was when they went to the core of the Earth, and there were these alien people, the ones in Atlantis, and they destroyed Atlantis, and I was very sad about that."

-- Participant 19, Female, NONC

"The part of thinking about how a family member would benefit got me thinking because that's a thing I'm actually struggling with my Dad about. That also makes me feel that I sit on my butt a lot and I should maybe not be a hypocrite. If I could get him to come out and take a walk with me, which doesn't always work. I got him to take one yesterday. It was the first time in a week. I can probably get him to do it once a week unless I trick him. That sort of stuff motivates me the most"

-- Participant 11, Female, CONT

There does not appear to be a common theme among what participants found memorable, but some participants in the Full-Interaction condition did mention they remembered how their character's past was revealed to them, which indicates that the mechanics used in the Full-Interaction game can be effective in getting the player's attention.

"The most interesting part is when you unlock stuff about yourself, rather than the other people, sometimes weird, to find out your history, and then atomic energy…"

-- Participant 46, Female, FULL

7.4.10. Life Impact

Apart from doing more physical activity and thinking more about taking action to change their behavior, several participants stated that the program also had other types of impact on their life: they started to talk to people more, specifically about physical activity, they started to eat healthier, and some said they had a better mood and better health after exercising because of the program. The following quotes are a few examples.

"I definitely really like some of the question homework which was given, like a person who goes to the gym, a friend of mine, to take tips from him. I actually did that, and he really motivated me to work out with him, and I went to work out with him. And it was really good. ... Now it's become an important part of my life, unlike before, which is not very regular."

-- Participant 33, Female, NONC

"I always thought of including exercise as part of my routine, but I was just not able to do that. Just always found some very good convincing excuse not to do that, but for this program, that has changed. I'm exercising when I can, or if I don't have time, I try to include exercise, not proper exercise, maybe just a brisk walk: I'm a developer so I code by standing. So not sitting all the time. So I've been doing exercise since. And I eat much more healthy food, and all of that has influenced my life."

-- Participant 24, Female, HWNL

Two participants mentioned that as part of progressing in the program, they began to change people around them, as suggested in the following quote.

"for my second homework which was how would exercise benefit someone whom I know, I was thinking of my friend so I called him and told him I was thinking how you can benefit from all this exercise and how you can really lose some weight. He said he will try."

-- Participant 98, Male, NONC

7.4.11. Art & Music

One of the concerns of creating the game using old public-domain comic books is that the art may be outdated, and the quality of the scanned images may not be satisfactory to the players., but the majority of participants expressed a liking of the art of the comic book, some explaining that the art seemed “appropriate” for the historical setting of the comic book. Several participants mentioned that some frames were reused, but it was only to state that they noticed the replicate frames rather than expressing any negative feeling towards it. Overall, the vintage art work served the game very well.

“Art work was pretty good. A little bit more colors would be better, to make it more engaging. But the drawing was really neat. I liked it. The scratches on the drawing make it feel like a comic. So that was super cool.”

-- Participant 65, Male, CONT

“I don’t know much about art, but it seems like top-tier art for a comic book and I know there’s a lot of fresh frames, and there was only a little bit of reuse of the frames, like the Captain looking at you or certain people looking at you and talking to you. But most of it was really very just cool and it did help to visualize the story more, so it’s pretty effective imagery.”

-- Participant 111, Male, FULL

Participants’ opinions of the music are divided. Some participants liked the music, commenting that the music fits the pace of the story, in that when an intense situation is about to occur, the music will change to reflect the tension, while others disliked the music, finding the music repetitive, mainly due to there being only two sound tracks, which may be fine for one or two sessions of game play, but lacking when the game extends to a few more sessions. Several participants also mentioned that they muted the music because they preferred to read without music, or they were in an environment where they could not play music.

"It's repetitive. I often turn the thing off. The style suits the visual I guess. That MIDI kind of sound. I didn't think the sound was much of a component of it the entire time."

-- Participant 11, Female, CONT

"When you're reading the novel. When you're playing a video game, there's often an element of suspense that's created through music. Because that's so common in video games, it's almost an expectation of somebody playing a game, and there should be that component to it. I think it was really cool because it created like an up and down, you know it wasn't just reading and you're like able to skim it really fast or go back or go forward necessarily in it, so the ability to have the music to help you through the story, I thought that was really good."

-- Participant 66, Female, FULL

"I didn't usually have the music on, because either I was doing it with my roommate in the room or something. I do remember it, yeah. I guess it made it seem… like a movie where something's happening, like you're in a meeting with the President."

-- Participant 46, Female, FULL

7.4.12. Contingency

One particular question asked during the interview has to do with the adherence method in the Contingency condition. For participants in the Contingency condition, I asked whether there was a homework assignment that they did not complete, and how they felt about not being able to continue playing the game until they completed it. The number of participants who experienced the homework incompletion is very small, because the majority of participants across all conditions completed all the homework assignments they were given. However, a few participants stated that they failed to complete their homework at least once, and had two distinctly different reactions to the response from the program: two participants chose to do the homework assignment after seeing they could not play the game until they finished the homework; one participant did not like the approach, and felt the punishment of not being able to play the game did not motivate him. The following quotes are from these participants. Part of the reason that a participant might not like the

punishment is that the participant is not that fond of the story to begin with, and it is likely that if the game is interesting to the participant, he or she is more likely to be inclined to complete the homework to play the game.

"The program asked me to come back when I completed it so I probably did it after a few hours I did it again. I wanted to read the comic and I didn't get to read it. I didn't get to read it so I had to do it so that I can read it."

-- Participant 65, Male, CONT

"One day (I did not complete the homework), and it wouldn't let me go on. I was like oh okay. I just did the homework and wait for the next day. I wish it would let me log in later."

-- Participant 21, Female, CONT

"The punishment that is not getting the next part of the story is not that bad, and the prize is not that attracting as well. It's good but it doesn't make me want to just do the assignment and get back to the next part of it."

-- Participant 27, Male, CONT

7.4.13. Future Usage

When asked how they would use the program after the debriefing session, when they would not be using the program due to a commitment to the study, the majority of participants claimed they would use the program at a similar frequency as before, or try to use it more. A small number of participants said they would use it less frequently, as mentioned by the following participant.

"I'd try to do it more often, at least once a day, because there were a few days that I couldn't manage because of my homework. So I'll try doing it. I'll try living up to what the homework tells me to do honestly. If it tells me to take 10 to 15 minutes of walk, I'll not cut it down to 5 minutes, I'll make sure it stays 15 minutes. I want to follow the program properly because I really think it can help me exercise regularly. So I'll follow it properly."

-- Participant 31, Female, HWNL

"I definitely want to make more of an effort to use it on a daily basis, because I think that's one of the benefits of the program. Using it on a daily basis really reinforces the idea of exercise regularly, think about your health, continue to do research, so I think that would probably be a reason to continuously, that would be something I try to aim."

-- Participant 66, Female, FULL

"I wouldn't change anything. Because it was kind of a pastime. I could get into it and I could finish it off."

-- Participant 100, Female, CONT

"I think I'm completely satisfied with this kind of program. So it's easy to download and it encourages you to return every day. Yeah, [I will use it] the same."

-- Participant 117, Male, NONC

A few participants mentioned they would try to give the homework assignments more thought than they did, and try to start doing more exercise as they progress through the program. Some participants also suggested adding functionalities to the program, such as a reminder to use the program every day, preferably on the phone, a set schedule to do exercise as part of the program, and a progress tracker so that they could see how many homework assignments they have completed. The following quotes include a few of these ideas.

"I guess I would maybe make the program what I did right before I exercised always, so I could get the mission, and the mission might be think about how exercise will make you feel better about your body, and then I can use that as motivation while I'm exercising. That would be a great idea actually. Maybe I'll do that. "

-- Participant 111, Male, FULL

"Yeah I would actually prefer to set up a reminder system to do it, because it needs at least 24 hours gap for every episode, and if I delay one episode by about 6 hours, it totally goes to the other half of the day. It ruins my next episode. Having some reminder somewhere in the middle of the day, around 6PM maybe every day would be better."

-- Participant 96, Male, NONC

"Now I would try to make it more like I exercise before I do it. Feeling like right before I play I'd go to the gym and then go and get on the game."

-- Participant 46, Female, FULL

7.5. Conclusions

The hypothesis testing confirmed an important hypotheses regarding games for health: game-based long-term health interventions overall significantly promote behavior change, which is consistent with the findings of decades of games for health research. However, the hypothesis testing also clearly pointed out a controversy: games for health do not necessarily outperform conventional, purely message-based interventions: Non-Contingency clearly underperformed the other conditions in terms of change in physical activity, homework completion rate, and several Trans-Theoretical Model-related measures. Even though Non-Contingency provides more engagement to the user compared to the Homework-Only condition, both theoretically and practically, it still underperformed a simple bland homework-based intervention. I believe this is because the game added in the Non-Contingency condition does not give players a meaningful relationship with the health behavior change intervention, and thus becomes a distraction from the main intervention, instead of an added attraction. This finding is also consistent with observations from the few existing studies that compared health games to alternative types of interventions. I also discovered a significant interaction effect between gender and study condition on participants' engagement with the program, their liking of the program and the likelihood of using the program as a way of relaxing. This is an important finding because it implies that well-designed health games can outperform conventional interventions in specific populations.

Exploratory tests showed that there are additional factors that play an important role in the outcomes of the intervention, such as liking of superhero comic books. It is clear that individuals who like superhero comic books gained more benefits in the Full-Interaction conditions, but not in the other conditions. It is also noticeable that a small number of participants in the Full-Interaction condition continued to complete the game even after the debriefing, voluntarily and without concern for any commitment, which did not happen in any of the other conditions. This suggests that the Full-Interaction game may have captured the inherent interest of some players. Therefore, finding the right audience for a health game may be as important as using a sound framework to design the game. Defining the player's preferred genre is an open field of research itself.

Participants in the Contingency and Full-Interaction conditions claimed to be less honest than their counterparts in the Homework-Only and Non-Contingency conditions, thus it appears that using reinforcement techniques to encourage players to complete homework assignments could lead to cheating. Some scrutiny on the validity of the player's homework progress can be implemented to prevent the players from cheating. However, there is no research in the games for health domain that addresses this issue as of now.

The analysis of the interviews shows several potentials of the DraGuNa framework: the architecture can incorporate features such as a reminder system, a scheduling system, and a progress tracker. As of this thesis, the DraGuNa framework is focused on incorporating a variety of theories to create a game experience, but as the data suggested, making the game a purely relaxing experience may hurt the intended health outcomes, and making the players somewhat obligated to use the system can potentially lead to more behavior change. The framework can also incorporate features of social networks, so that more players can use the game as a shared experience.

The study is also subject to several limitations. First, the sample size is relatively small: with less than 30 participants in each condition returning to the debriefing, the sample does not provide enough power for several key analyses. Second, the participant sample is composed primarily of students, and as several participants suggested that they treated the program as a sort of homework, the habits of students may have yielded to biased outcomes. Third, as mentioned earlier,

behavior change interventions typically take months if not years to fully take effect. The short scope of time in which this study was conducted did not allow participants to fully engage in behavior change, and because no follow-up measures were collected, it is impossible to tell if the behavior change observed at the end of the study would last within the next 6 months to a year.

Chapter 8. Conclusion

8.1. Lessons for Game Design

This dissertation described the DraGuNa framework, a complete system for creating narrative-based health games, which a game designer can follow step-by-step to create a game from the ground up. What I did not describe in this dissertation is some of the lessons that I've learned from the development of the Adventures of the Atomic Submarine. These lessons warrant some discussion because they provide critical information for designers of future health games, so that those designers can avoid some of the pitfalls that I experienced.

The most important lesson that I learned from designing Adventures of the Atomic Submarine is balancing quality and scale. I began the game design with a way more ambitious goal than the final product. I planned to transform a grand story into a game experience, and I chose to use the Count of Monte Cristo as my basic story, but with help from my advisor and my committee, I soon realized that the story was too long for a project that I will be working on alone, especially since I would have to product a large amount of art work, because I would be adapting a story from a novel. Had I followed through with my initial idea, I might still be able to create a game, but the quality of the game may be inferior. However, creating a longer story makes a longer intervention more practical, and thus an experiment conducted using such a game may yield valuable information. This is a dilemma faced not only by researchers such as myself, but also by indie and commercial game designers all the time. Game design is about compromise as much as about creativity and craftsmanship. Therefore, game designers using the DraGuNa framework must carefully balance the quality and scale of their game, depending on the length of the intervention and the available resources, among other factors.

A second lesson from my game design process is usability testing. I performed pilot usability testing with a few colleagues from my laboratory before launching the study. Although my colleagues had no complaints with my final prototype, my participants had different ideas. One prevalent problem that participants encountered was internet connection issues. I expected each participant to be just like me and my colleagues – who have a stable Internet connection and perhaps the ability to detect

an Internet issue when it occurs – but the reality is most of my participants are students using the campus Wi-Fi, and some of them played the game in the library. When the game client disconnected from the server due to an Internet issue, the game did not present the user with a clear diagnosis. Several users stated in the debriefing session that the game “froze”, not knowing that it was due to an Internet failure. Such issues can critically affect the quality of an intervention, if a large number of users experience it. Therefore, I urge health game designers to test their games with actual target audience members before launching their games. It is even better to plan such testing prior to the game design starts, so that extra time can be budgeted for the project.

Another lesson that I learned is the value of collaborations. I worked on Adventures of the Atomic Submarine alone for the most part (except for advice from my committee), and it is not until near the end of the development process that I began my collaboration with a student from Berklee College of Music on the sound track for the game. I expected the effort to be tedious and complicated, but it turned out to be the opposite, and the product pleasant and professional. In retrospect, I could have worked with a storywriter and an artist to create the game from the beginning. The resulting product may not be of a higher quality, but it will be more modern, and perhaps more familiar for the majority of the players. Working with others would also have lifted a significant work load of finding comic books and trimming frames from my own shoulders. Therefore, I’d like to urge individual health game designers to collaborate with talents from art, literature and music to create their games. These efforts may not be as expensive or difficult to come about as a beginner would imagine, if the appropriate recognition is provided.

Finally, it must be noted that I’ve encountered great difficulties trying to separate design from research. Game design is a highly creative process, and although methodologies and frameworks can be employed to summarize parts of the process, the essential parts of the design process is dependent on the individual creativity of the game designer. Even with the help from the DraGuNa framework, a health game designer still must make a large number of creative decisions to create or adapt a story, and to create the game mechanics. The success of a game is determined both by the adoption of a sound methodology, as well as by the execution of the game designer. This

conflict reflects an even bigger problem that exists between the disciplines of game design and behavioral medicine: behavioral medicine and health sciences in general rely on well-designed clinical trials to approve or disapprove a methodology, and when games are incorporated as part of a health behavior intervention, the strict principles that apply to clinical trials are also considered to be important standards for games for health research; on the other hand, well-known game designers do not talk about frameworks and methodologies, but rather, they focus on how their game design skills developed through decades of experience. Behavioral medicine is a science, and behavioral medicine researchers emphasize the employment of a sound framework and the demonstration of clinical significance, whereas game design is an art, and game designers value a rich portfolio more than expertise in game design methodologies. For games for health to truly thrive, a balance between these two disciplines must be identified. This dissertation does not provide an answer to where this balance lies. Rather, this dissertation provides evidence that the division between these two disciplines are significant, and a harmonious combination of these disciplines and their methods requires the joint efforts of artists and scientists alike.

8.2. Contributions of This Thesis

This thesis is motivated by the rapid growth of games for health in the past several decades, and by the lack of sound game design principles as well as comprehensive comparison studies thereof. This thesis has several contributions both to the field of games for health and to the intelligent narrative community.

First, this thesis is among the limited amount of efforts that recognizes the importance of using game design principles in the design of health games. According to my examination of the games for health field, detailed in Chapter 3, only a very small number of health games reported using established game design methods, and no narrative-based health game has ever reported employing any methodology to guide the story writing. I argue that successful health games are bred from a solid understanding of successful game design principles and successful story-writing methods. This thesis provides the very necessary drama and game design theories that can serve as useful tools in the hands of games for health designers.

Second, this thesis is the first attempt to create a fully-usable framework for the design of games for health. The establishment of the DraGuNa framework helps game designers streamline their work, making the creation of narrative-based health games easier and more procedural. This framework especially helps behavior medicine researchers who are usually short in time and funding: these researchers can now use the DraGuNa framework to adapt an existing story into their own behavior change intervention.

Third, the study described in this thesis is the only one up to this date that compares multiple methods of designing a health game, and it is also the only study that attempts to decompose the elements that potentially cause a health game player to experience behavior change gains: engagement and adherence. Although the study is subject to several limitations, as discussed in Section 7.5, it has demonstrated that participants' engagement and adherence to a health game may lead to behavior change, and these factors can be manipulated through the design of the health game.

The study also confirms important findings in games for health research as well as points out weaknesses in previous work: consistent with findings from previous work, the game created in this work lead to significant improvements in the participants' behavior change, but when compared to pure message-based intervention, a well-designed health game can only outperform for a specific portion of the population, in this case, male participants, and a poorly-designed health game may underperform the conventional intervention. In other word, although the rapid growth of games for health may have created a sense that games for health is the future for health behavior change interventions, this study has shown that health games must be designed with sound design and behavior change theories and practices. Simply adding a game to a behavior change intervention may not do the trick, and even for games designed with sound principles, many other factors such as audience preferences and user honesty must be taken into account, which requires future research to investigate and understand. Overall, games for health may outperform conventional behavior change for the right audience, one which likes and is predisposed to the genre of the

health game – in our case, male participants – but the games can also underperform for the audience that is not predisposed to the games' genre, and potentially drive these players away.

Finally, this thesis also contributes to the field of intelligent narrative technologies by expanding its application to health behavior change intervention, an area of research the intelligent narrative community has rarely tread upon. Through the development of a Narrative Selector that serves multiple functions, from providing positive reinforcement to creating a sense of tailored intervention, this thesis shows that integrating intelligent narrative technologies can greatly benefit games for health and encourages future attempts of adapting other algorithms, such as drama managers and narrative planners, in the research of games for health.

8.3. Future Work

8.3.1. Extending DraGuNa

The feedback from participants suggests that several changes can be made to the game to create a more enjoyable experience, some of which fall into usability and design issues, such as the constraint of using the program up to once a day, page roll-back issues, and the display of text bubbles. However, a few issues that arose from the interviews point to ways of creating a better design framework.

First, several users suggested in the interview a need for the behavior change intervention to adapt to any change in the player's health behavior. As the current system architecture stands, when a player's Stage of Change alters, there is nothing the system would do to cater to this change, which caused frustration in players who wanted missions about "actual exercise". When the DraGuNa framework was initially designed, a strategy was developed to match the game's progress to the player's Stage of Change. The strategy emerged from the observation that Campbell's Hero's Journey storytelling model has many resemblances to the Trans-Theoretical Model, and the twelve steps of the Hero's Journey can be mapped on to the five Stages of Change in the Trans-Theoretical Model. The Hero's Journey model has been illustrated in Figure 3.1, and Figure 8.3 that follows shows the mapping between these two models.

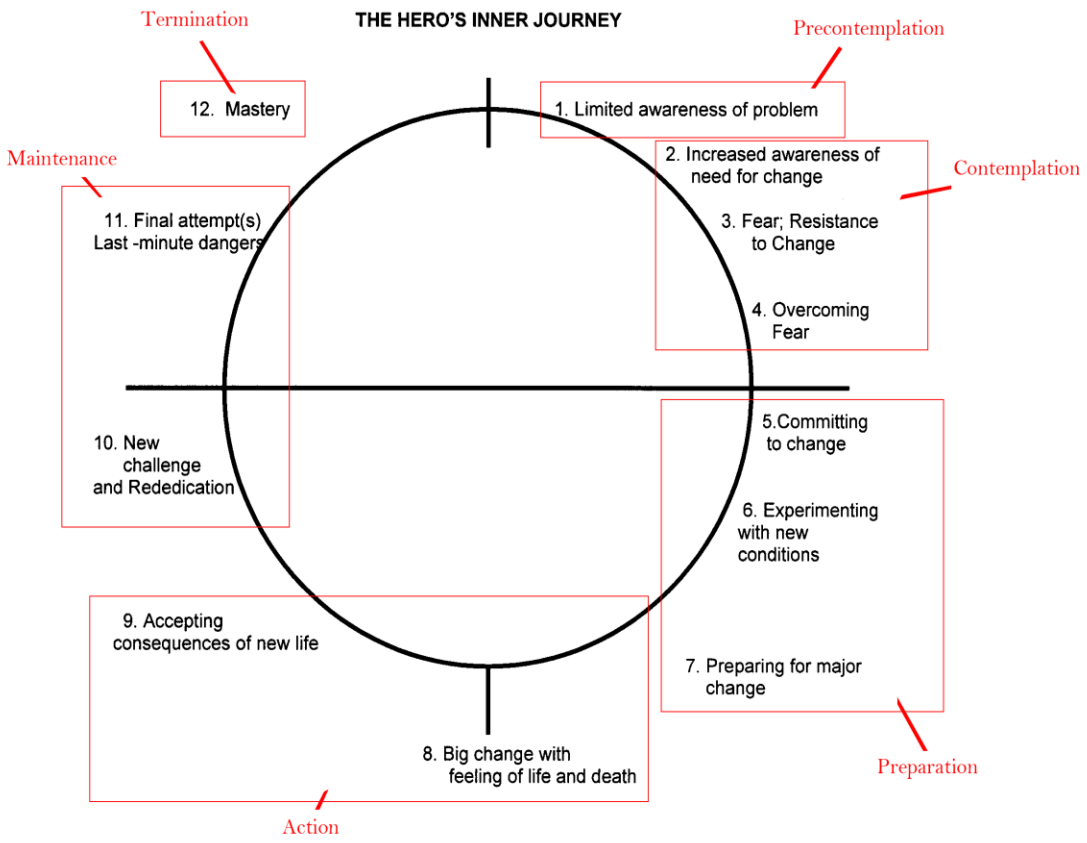

Figure 8.1. A mapping between the Hero's Inner Journey and the Trans-Theoretical Model

Matching the player's behavior change to the storytelling faces two significant challenges. The first challenge is measuring the player's health behavior periodically. A straightforward solution is to assess the player's Stage of Change, and potentially other TTM-related measures through a series of questionnaires periodically, but this may break the flow of the game. Another solution is to infer the player's behavior through the amount of homework completed. Because each homework assignment belongs to a Process of Change in the DraGuNa framework, and the majority of Processes of Change cross over multiple Stages of Change, the player's completion of homework within certain Processes of Change may indicate their readiness to progress to the next Stage of Change. Through a statistical model or a machine learning algorithm, it is possible for the game to assess the player's progress without using questionnaires and advance the game accordingly. The second challenge is that health behavior change typically takes a long period of time, sometimes multiple years, and the lifecycle of a video game is typically a few days or a few weeks. It is almost

impossible to lead a player through an entire health behavior change process through the use of one game. Therefore, it is important to decide when a game should reach a conclusion, even though the player's behavior change is not complete, without the game dragging on for too long and becoming boring. Another inspiration can be taken from recent AAA titles such as Skyrim and Dragon Age: Inquisition, where a player can spend over 100 hours completing side quests. When implemented professionally, side quests, just like satellite stories in Adventures of the Atomic Submarine, can enhance the main story, and if the player is given the choice of completing a large number of side quests or satellite stories, a game can keep the player company for several months, which provides a much larger window for health behavior change.

The second possible extension to the DraGuNa framework is to add a mobile element. Several participants have complained about the fact that it was difficult to fit playing the game in their schedule, and they suggested a number of solutions: having a reminder, having a scheduling system, or having a mobile version that they can play when their computers are not available. These features can all be implemented through a mobile application. What's more, mobile games have a completely different repertoire of mechanics from computer and console games, and an interesting topic would be to understand what can be done uniquely on the mobile platform. Currently, many smart phones are capable of tracking the user's step counts, essentially working as a pedometer. For health behavior change other than physical activity, there is almost at least an app for each behavior on major smart phones. The DraGuNa framework can not only guide the development of a mobile game and a reminder or scheduling system, but also integrate the functionalities of a phone to enhance the user experience.

The third extension lies in the social aspect of games. Social networks have provided a unique platform for gaming, and the emerging industry of social gaming has gained a solid footing in recent years. However, social games are rarely narrative based, and using the DraGuNa framework to design social games can be challenging. Nonetheless, certain social elements can be added to the framework. As some participants have mentioned, they played Adventures of the Atomic Submarine as a shared experience, by having their significant other read the story to them, or

discussing the story and homework assignments with their friends. There are potentials in allowing players to interact with each other's online profile while playing a game. This is a possible direction of extending the DraGuNa framework, and at the same time an interesting area of future research.

8.3.2. The Future of Games for Health

The current study delivered an important message: better evaluation studies need to be conducted for health games. The majority of evaluation studies for health games focused on whether the game lead to significant behavior change or knowledge gain in the player, but as the current study demonstrated, even if a health game can lead to behavior change, it can still underperform a health intervention with similar content and no game element. When an alternative, more traditional kind of intervention is available and more beneficial to the user, giving the user an underperforming game-based intervention should not be recommended, and sometimes may be unethical. Therefore, it is crucial that future games for health be designed to stand the test against a no-game intervention with identical health content. Games for health also need to clearly define the target audience, because as has been shown in this thesis, while certain types of players benefit greatly from a well-designed health game, others may prefer a more traditional, schoolwork-like intervention.

This thesis also provides evidence that narrative-based health games can be effective in behavior change, especially in physical activity. When games for health first emerged, in the domain of physical activity, designers and researchers focused on ways to get players moving while playing games, hence the Wii Fit and Dance Dance Revolution came into existence. However, the effectiveness of these active games in behavior change has been the topic of ongoing debate, as mentioned in Chapter 3. The current study has pointed the research of health games, especially those focused on promoting physical activity, to a new direction: using a narrative-based game can lead to significant change in a player's physical activity. Although this study is restricted to physical activity, I hypothesize that using the DraGuNa framework to design games to address behaviors other than physical activity may also be effective, but further research is required to draw concrete conclusions.

The DraGuNa framework is rooted heavily in drama and interactive drama theory, as well as in the Trans-Theoretical Model. However, it is important to acknowledge the large number of theories in these fields that are not mentioned in this thesis. Although a vast amount of research in interactive drama is conducted on classic drama, recent developments in this field have turned to other genres. The same can happen to games for health: as the field of games for health develops, health games may no longer be confined in the current spectrum of games for health genres, i.e. role-playing, action, and puzzle games. Other popular genres of games, such as strategy games, card games, and online battle arena games, etc. may also be proper media for health interventions. This thesis explored visual novels, a genre that is rarely used as games for health, but is recently revived and re-invented by popular games such as Danganronpa, the Walking Dead and the Game of Thrones, which are easy to make and can serve as a good test-bed for future games for health research.

The DraGuNa framework also provides a methodology for creating a game from existing stories, but as I've noted, a game designer must carefully decide whether using an existing story fits the game's purpose. The most straightforward way of creating a game through an existing story is to use an existing narrative-based game, but this requires the game designer to have access to the source code of said game to incorporate health behavior change into the game. On the other hand, the way that requires the most work is to come up with the original story for a health game, which gives the game designer a great amount of flexibility in the game design, but requires complete confidence that the game designer or the game design team can come up with a high-quality story. Somewhere in between these two approaches lies what I've done in this dissertation, i.e. using a comic book by rearranging the frames and modifying texts, as well as a series of other methods, such as reusing TV shows or video clips, and reusing the story from a novel or interactive fiction. Each approach bestows different levels of convenience and restriction on the game designer. For example, reusing a novel gives the game designer flexibility to move satellite stories around and incorporating health messages in a variety of places, but the designer has to create a full game except for the story; whereas a game designer reusing video clips can take on a similar approach as I did in this dissertation, but the game designer loses flexibility in the process of incorporating health messages, and the game also ends up to be a non-standard genre of game, whose target

audience may be difficult to define. The pros and cons of each approach on the spectrum of story reuse should be explored for the design of future games for health.

For a long time, games for health have focused on children and adolescents. When compared with a textbook health education, a game-based health education is naturally more appealing to children and adolescents. The study described in this dissertation has shown that health games can work well for adults too, and some adults also prefer a game-based intervention to a traditional, textbook-like intervention. Compared to children, to whom play is an integral part of life, adults may be more difficult to please with a health game, but promoting positive health behavior change in adults is equally important. Therefore, it is crucial that future games for health research pay more attention to the health of adults.

Another contribution of this thesis is the proposal of a model to understand the effect of engagement and adherence techniques on a health game player's behavior. The model proposed in Section 7.2 depicts a rather complex research model of player behavior in health games. It confirms many findings in behavior medicine and points to the direction of a unified model of understanding the role of engagement and adherence in games for health. Future research should be conducted as attempts to validate the different parts of this model.

Finally, a significant obstacle that games for health are faced with is the border between the lab and the real world. Evaluations conducted in a lab setting may not represent player behavior in a naturalistic setting (Baranowski et al. 2012), but the majority of games for health evaluation studies still occur in a lab setting. Some recent studies were conducted in participants' homes, but these also tend to be obligatory, where health games were given to parents or teachers at school, who would then give the games to their children or students respectively. It is difficult to tell if participants in these studies may feel obligated to complete the games. In the current study, a majority of participants clearly stated that they were motivated to use the program primarily by their commitment to the study, and although a large number of participants claimed that they would continue using the program after the debriefing, very few did. However, it is worth noting that in the current study, the participants who continued using the program after the debriefing are all in the

Full-Interaction condition. This may imply that a well-designed health game holds the potential to make participants want to play it voluntarily. With continued research efforts, the DraGuNa framework can be improved so that games designed using this framework provide a sufficiently engaging and adhering experience and a study run on participants who voluntarily sign up to play the game may be possible. Conducting a study with participants who want to play a health game because it appears to be fun and beneficial can be a noble goal of a games for health researcher.

I hereby propose a vision for the future of games for health: individuals who want to change a behavior, form a habit, or simply to get healthier, could browse through the games in their Xbox store or Steam store to find a game that could help them achieve their goal; they would purchase the game and be immersed in a few weeks or months of enjoyable experience; they could share their experiences with their friends or family; they could set up personal goals as part of the game play and enjoy the pleasure of achievement; they would complete the game feeling that their behavior has indeed changed or started changing; and they might replay the game to continue on the path of change, or purchase another game addressing the same issue, but designed for more advanced players. It is important that games for health eventually become a mature industry and no longer confined to the laboratories, because laboratories and clinics may be good places to test the efficacy of an intervention, yet the quality of the games must be tested separately. Laboratories can certainly be used to test the quality of health games, through usability tests and playability tests, but the ultimate success of a game, measured by the audience's reception, cannot be effectively tested without the harsh judgment of the market, which has been proven over and over by the commercial video game industry. To develop the next-generation games for health, designers must strive to create higher quality games, and high quality games cannot be created without a sound framework and a firm understanding of the theories of game design, and in many cases, drama. The DraGuNa framework and its validation in this thesis may serve as a tool to create better games, as well as a stepping stone for better game design frameworks.

Appendix A: Physical Activity Homework by Process of Change

Consciousness Raising (PC, C)
1. Search for online articles about the pros and cons of physical exercise.
2. Search for videos online about how exercising changed people's lives.
3. Pay attention to movies or TV shows, or reflect on the movies and TV shows you've watched before, where a character has the habit of exercising. What do you think about those characters?
4. Search online for the differences between cardiovascular exercise and strength training.
5. Find out the details about one particular exercise program that lasts more than three months.
6. Find out what is moderate intensity exercise and its pros and cons.

Dramatic Relief (PC, C)
1. Think of one friend or family member who could benefit from exercising.
2. Reflect on movies or TV shows you've seen and think of one character who could benefit from exercising.
3. Think of a person you love in your social circle. How would he or she become healthier if he or she exercises?
4. Think of one thing you'd like to improve in your life. How would exercise and gaining more energy help you do it better?
5. If you don't exercise, what would be the ill consequences to your health in 20 years?

Environmental Reevaluation (PC, C)
1. How would people around you think of you differently if you exercise?
2. How would the society change if more people exercise regularly?
3. If more people exercise, how do you think the health care system will be different?
4. Look at your most recent hospital bills and check-up results. How would exercising affect your health care bills?

Social Liberation (PC, C)
1. Ask two friends about their opinions of exercise. Do they know that exercise is good for them?
2. When you go to work or go to school, ask co-workers or classmates to see how many of them are making exercise part of their regular life.
3. Look around in your neighborhood, within 20 minutes of travel, find out how many gyms there are.
4. Take a walk around the nearest park. How many people do you see running or doing sports?
5. Think of three celebrities you know. Look online for whether they've advertised that they exercise regularly.

Self-Reevaluation (C, P)
1. Think about conditions you currently have, including things as trivial as an occasional back-pain. How will you feel differently if you exercise regularly?
2. Imagine that you are exercising regularly. Will that make you a healthier person?
3. Imagine that you are exercising regularly. Will that make you happier?
4. Imagine that you are exercising regularly. Will that make you more confident?
5. Take some time to meditate quietly, and think about how you will feel differently if you exercise as compared to when you are not.

Self-Liberation (P, A)
1. How many times have you gone for a walk last week? Do you think you can increase the number of days you walk in the next week?
2. Recall your feelings when you went for a walk even though you didn't want to. Do you think you can keep exercising regularly if you try hard enough?
3. Think of one thing that you struggled with and succeeded in before. Do you think you can use the same thoughts that helped you succeed to encourage yourself to continue to exercise?

4. Look online for blog posts about how to overcome difficulties in exercise.
5. Think about an exercise goal you want to reach by the end of the year. Make it a New Year's resolution.
6. Think about all the research you've done about exercising. Make it happen now. Take small steps. Find a time when you're comfortable to walk 10 minutes.
7. Think about the time you've walked and how you felt at the end. Do you think you can walk a little longer next time?

Helping Relationships (P, A, M)
1. Think of a friend who can help you with exercising. Tell the friend about the difficult times that you've faced when exercising. Listen to their opinions.
2. Find someone you can trust. Ask them whether they can play the following game with you: at the beginning of each week, tell this person your weekly exercise goals and give them a small amount of money that you would feel bad if you lost. At the end of the week, if you meet your exercise goals, you may take the money back. Otherwise, your trusted person will keep the money.
3. Talk to someone you know who exercises regularly. Ask them how they exercise differently from you.
4. Ask your friends whether they can exercise with you. Even if it is only once a week, schedule a time to work out together with a friend and make it a habit.
5. Think of how you and your exercise partner work out differently. Share a tip with them.

Counter Conditioning (P, A, M)
1. In the afternoon or after work, when you feel tired, take a walk instead of taking a nap. See if that makes you feel better.
2. Next time when you feel tired before going to exercise, tell yourself to go exercising anyway. See if you feel better afterward.
3. Next time when you want to relax by watching TV, browsing the internet, or eating snacks, take a walk instead. See if that makes you feel better.
4. Next time when you are stressed out or don't know what to do with your work or study, go for a walk. See what it does to your stress.
5. Next time when you need to take a bus or drive somewhere, plan some extra time and get off the bus or park your car further away from your destination. Walk the extra miles for your exercise of the day.

Reinforcement Management (A, M)
1. After you take a walk next time, tell yourself that you've done a good job. If this makes you feel good, encourage yourself in this way every time after you exercise.
2. After you take a walk next time, pay attention to your mood. If you feel happier than before you exercise, tell yourself this is a good reason to exercise even if you don't want to.
3. If you meet your walking goal for the week, treat yourself with a frozen yogurt, cook yourself something nice, or get yourself a gift that you wanted to have for a long time.
4. Ask your exercise partner to help each other with your exercise goals. If one of you doesn't meet your goal, this person has to give the other person a small gift, maybe buying a meal or a book.
5. Think of something you'd like to do, such as playing video games, watching movies, or reading novels. Do these things only after you finish your exercise goal for that day.

Stimulus Control (A, M)
1. Put on special clothes suitable for exercising when you go for a walk. Put these clothes in a place where you can easily see and access.
2. If you're doing more exercise than walking, put your exercise equipment or gym membership card somewhere you can easily see. If you rent a small apartment, consider putting your equipment or gym card near your TV or computer.
3. Keep your walking clothes clean. Schedule your laundry frequently so you always have clean clothes when you want to exercise.
4. Mark your exercise time on your calendar. If you are using a calendar on your computer or your phone, set an alarm to remind yourself it is time to exercise.

5. Put your favorite music on your phone and listen to them when you take a walk next time.

Abbreviations of stages of change:

PC: Pre-Contemplation

C: Contemplation

P: Preparation

A: Action

M: Maintenance

Appendix B: Basic Story of Bill Battle and the Atomic Sub

Issue 1: The construction of the atomic submarine is barely finished when the President of the United States summoned Bill Battle and requested that he and three other experts of his choosing pilot the vessel. When Champ, Doc and Tony were found by Bill Battle and gathered at the White House, they were asked to dismantle a potential Russian plot with the atomic submarine. However, they discovered the invasion of an alien civilization from Mercury instead, which had constructed an underwater city called the Atlantis and used flying saucers to scout the Earth. The atomic commandos were caught by a flying saucer, but managed to escape from the alien city. In the end, the commandos fired torpedoes from the atomic sub to destroy Atlantis and the invaders from Mercury.

Issue 2: Mysterious humanoid creatures from the center of the Earth destroyed engines of the atomic sub and kidnapped the United States Congress. The atomic commandos were just in time to prevent the President from being kidnapped as well. The creatures demanded that humans stop using any atomic energy because it threatened their lives. The commandos rejected the threat, which enraged the creatures from central Earth, and they began to unleash all volcanoes on Earth, but the atomic commandos infiltrated their base and destroyed their entire civilization.

Issue 3: An atomic bomb originated from the Moon was dropped not far from the atomic sub. The incident led to the atomic commandos uncovering a Russian base on the Moon, which was going to launch nuclear missiles on to America undetected. A young boy, Jonnie Flint, requested to join

the atomic commandos and showed his invention the Telepathor, a device used to communicate via thoughts. However, Bill Battle rejected the boy's request because he was too young. Jonnie snuck on the submarine nonetheless. The atomic commandos eventually decided to install space traveling devices to the atomic submarine, and flew to the Moon. They were, however, captured by the Moon-men. The Moon-men wanted to kill the commandos, as they were massacred by the Russians who set up base on the Moon and thus thought all humans were evil. Jonnie used the Telepathor to communicate with the commandos and came to their rescue. The commandos and Jonnie then scouted the Moon, discovered the Russian base, and united forces with the Moon-men to eliminate the Russian base.

Issue 4: The atomic commandos were asked to guard Professor McDougald to finish his research on a biotic possessing extraordinary drying qualities on a small island. During the mission, Russian spies infiltrated the island, kidnapped McDougald and killed Tony. The commandos went on to investigate the incident and to avenge Tony. They found the professor killed, but the information of a location was left on his arm. The commandos followed the piece of intelligence, only to find out it was a trap set up by Russia to capture the atomic sub. When the atomic commandos were captured, they were told that McDougald's research would be combined with a vampiric plant to create a deadly seed, once spread across America, will turn the country to a wasteland. The commandos were once again saved by Jonnie's Telepathor. They chased down the Russian scientist who held the seeds and destroyed his aircraft.

Issue 5: The atomic commandos acquired intelligence of a Chinese submarine shipping important espionage information sinking near US borders. Bill and Jonnie dived into deep water and discovered the sunken submarine. However, when Jonnie entered the submarine, it trapped him inside and sailed to China. The Chinese submarine crew revealed this was a plot to capture Bill, but they decided to extract information from Jonnie instead. Bill and Champ landed in China through parachutes and located Jonnie through a mini Telepathor. However, Jonnie revealed information he gathered that China had established a nuclear missile base in the Arctic, ready to launch

missiles to the United States. The atomic commandos then upgraded the submarine's hull and infiltrated the base among icebergs, putting a stop to yet another disaster that was to befall America.

Issue 6: Major cities all over the world were suddenly attacked by high speed round-shaped flying objects, from which humanoid creatures from the Antarctic invaded the human world. The atomic commandos were once again summoned to the White House, where Bill convinced the President to create an atomic bomb of unprecedented power. The US air force dropped the atomic submarine, which held the atomic bomb, on top of the Antarctic. The atomic sub's frontal drill pierced through the thick layer of ice of the Antarctic, and the bomb was dropped deep down inside the origin of the Antarctic invasion. The bomb created a grand wave of water, covering the Antarctic civilization, which froze it to the end of time.

Issue 7: The atomic commandos were on a patrol when they were called back to Washington by the secret service. Bill found out his old ravel Peters had become head of the secret service and wanted control of the atomic commandos. Bill decided to teach Peters a lesson by disguising as Russia's espionage director. However, the commandos encountered the real espionage director of Russia on their way to the secret service, and found Peters killed. They chased down the spy and acquired information on an all-out attack on the United States organized by the Soviet Union before killing him in a car crash. The atomic commandos analyzed the information and struck three locations at once to put a stop to the plot. Jonnie once again rescued the commandos, and was rewarded the title of a senior atomic commando.

Appendix C: Characters in Adventures of the Atomic Submarine

Tony Gardello

Tony`s father was among the soldiers who died in World War I. He grew up with two sisters and a mother working two jobs. The first time he got caught was when he tried to steal a loaf of bread at the age of eight. He hadn't been eating at all and really wanted some food. He was beaten up and tied up, where he struggled to escape from ropes with his skinny body for the first time in his life. Later he would be caught several times for stealing, but he would escape each time. He came to know Houdini when later he was working in a circus. He admired Houdini, and aspired to become like him. During World War II, many men like him were summoned to war, but he just ran, far away from the circus, from where everybody knew him. He was afraid of dying like his father. He performed the grandest escape of his life.

Tony survived mostly by stealing. He had affairs with many women in his life, but never wanted to settle down. Part of him was afraid that his children would suffer like he did. He started his own circus, and was soon known as Gardello the Great.

When he was summoned by Washington, he was seeing a woman named Jessica Sfeir. Tony was deeply in love, and wanted a more stable life. This time he decided not to run away. He wanted to take the glorious job, and return a hero.

Dr. Edwin Blake

When World War II broke, Edwin just received his doctorate degree. He first worked as a researcher in the civil industries, that is, until the United States became fully engaged in the war, and no job would be available for a physicist outside of weapon development projects.

Edwin was honored to work with Dr. Oppenheimer on Project Manhattan in the late days of the war. He believed that nuclear weapons would become the ultimate gateway to world peace. But he was only a young scientist back then, and Dr. Oppenheimer strongly disagreed with his ideas. Soon

after the first nuclear missile was launched to Japan, Edwin resigned from Project Manhattan and went back to his home, teaching in a small university.

Years had past and Edwin heard word of a new atomic submarine being constructed in the United States. On the one hand, he wanted to prove he was right, that if Washington took his advice back then, the world would have been a better place since the Cold War and he himself would not have wasted many years in a suburban college doing research only by himself. On the other hand, however, Edwin was not sure whether he was right. The more he had observed the world, the more he agreed with Dr. Oppenheimer's judgment.

When he was summoned by Washington to commandeer the atomic sub, he considered it an opportunity not to prove himself right, but to show himself what is right.

Champ David Ruggles

David was a deputy in a small town. It was a simple life he led. He was good friends with the sheriff Luke Whitehead. They would go out in the town most of the week, patrolling, and helping the older folks and the kids in town with their businesses. In the last year of the war, however, everything changed.

One day, Luke got killed by a German spy. The man was fleeing from a nearby city, his identity discovered. Luke stopped him, because of his unfamiliar face and his suspicious behavior. The man shot Luke dead at the scene.

David was outrageous upon hearing this. He tracked down the spy and killed him. David was investigated by the federal bureau, but David was simply filled with rage and sought revenge for his old pal. They let David go in the end, but the man was no longer the same. He hated the war that brought a deadly man to his town and got his friend killed. He vowed to protect his town and his country from anything that would bring such ill fate to them again.

When he was summoned by Washington, he jumped in a joy. He wanted nothing other than killing enemies of America.

Jonnie Flint

Jonnie Flint was a young aspiring boy with outstanding expertise in physics. Most didn't know that Jonnie was a relative of Dr. Oppenheimer, and the knowledgeable scientist's influence on Jonnie cannot be overestimated.

Jonnie wanted to become someone like Oppenheimer, but the Flint family, politicians to the core, had long shunned the scientist due to his connections to the American communists. However, Jonnie met the old man a few times, and during their meetings, Oppenheimer would tell the young boy stories of his inventions, from the atomic bomb to the atomic soldier. Jonnie was inspired by these stories.

Jonnie's parents once told Jonnie about the atomic sub. In one of his father's dinner tales, Jonnie heard of a strange human who disappeared in World War II and reappeared on a beach. Jonnie then decided to join the atomic commandos to look at the stranger in person.

The telepathor wasn't really Jonnie's invention. Dr. Oppenheimer had many inventions yet to be revealed to the world, and Jonnie stole one as his ticket to ride. Jonnie had one goal: to look at Oppenheimer's proudest invention, the atomic soldier, and to learn Oppenheimer's vision of the world from the special soldier.

Bill Tyler

Bill Tyler was an elite pilot and star secret service man during World War II. After the war, he spent a long time alone, trying to forget what happened at the end of the war, when he and our protagonist, the atomic soldier, both crash landed in Japan, and happened to be in the middle of the Hiroshima nuclear strike.

What happened was beyond Bill's imagination. While the entire island was turned to a wasteland, he alone survived. However, he could not find the atomic soldier or a corpse, so he just assumed that his good partner died in the nuclear strike. He was very sad for a good number of years,

thinking he was responsible for a good soldier's death, until in 1951, he was told that the atomic soldier was discovered on a beach on the western coast, and would be working with him again.

Bill was shocked that the atomic soldier could not remember anything, but he thought it was a miracle in itself that they both lived. However, he took this as a chance to redeem his mistakes. In Bill's memories, the atomic soldier was an ideal fighter, dedicated to the job, and an action taker to the core. Bill took responsibility to ensure that the resurrected soldier become the same.

Appendix D: Questionnaires for the Evaluation Study

PAR-Q & You (CSEP 2002, Thomas et al. 1992)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
   Yes No

2. Do you feel pain in your chest when you do physical activity?
   Yes No

3. In the past month, have you had chest pain when you were not doing physical activity?
   Yes No

4. Do you lose your balance because of dizziness or do you ever lose consciousness?
   Yes No

5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?
   Yes No

6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
   Yes No

7. Do you know of any other reason why you should not do physical activity?
   Yes No

Socio-Demographics Questionnaire

Please take a moment and answer a few questions about yourself:

Date of Birth:_____

Sex: M / F

Ethnic Background (check one):

Asian or Pacific Islander	____
Anglo-American	____
American Indian	____
Black or African American	____
European, Not of Hispanic Origin	____
Hispanic/Latino	____

Marital Status (check one):

Single	____
Married/living with someone	____
Divorced/Separated	____
Widowed	____

Last grade of school completed (check one):

Less than high school (0-8)	____
Some high school	____
High school graduate or GED	____
Technical school education	____
Some college	____
College graduate	____
Advanced degree	____

Occupation: _____

How often do you read books (check one):

Never	____
Less than once a week	____
Once a week	____
A few times a week	____
Every day	____

How much experience do you have with computers (check one):

I've never used one.	____
I've tried one a few times.	____
I use one regularly.	____

I'm an expert. ____

How do you feel about using computers (check one):

I don't like them. ____
They're OK. ____
They can be useful. ____
I love playing with them. ____

How much experience do you have with comic books (check one):

I've never read them. ____
I've read a few. ____
I read them regularly. ____
I'm really into it. ____

How do you feel about comic books (check one):

I don't like them. ____
They're OK. ____
They can be good. ____
I love reading them. ____

Which genre(s) of comic books do you like (check all that apply):

Adventure ____
Fantasy ____
Horror ____
Humor ____
Romance ____
Sci-Fi ____
Superhero ____
War/Forces ____
Other (please specify) ____

Stage of Change Assessment Questionnaire (Marcus et al. 1992, Norman et al. 1998)

Regular Exercise is any planned physical activity (e.g., brisk walking, aerobics, jogging, bicycling, swimming, rowing, etc.) performed to increase physical fitness. Such activity should be performed 3 to 5 times per week for 20-60 minutes per session. Exercise does not have to be painful to be effective but should be done at a level that increases your breathing rate and causes you to break a sweat.

Question:

Do you exercise regularly according to that definition?

Yes, I have been for MORE than 6 months.

Yes, I have been for LESS than 6 months.

No, but I intend to in the next 30 days.

No, but I intend to in the next 6 months.

No, and I do NOT intend to in the next 6 months..

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE (Hagströmer et al. 2006)

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** and **moderate** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal.

PART 1: JOB-RELATED PHYSICAL ACTIVITY

The first section is about your work. This includes paid jobs, farming, volunteer work, course work, and any other unpaid work that you did outside your home. Do not include unpaid work you might do around your home, like housework, yard work, general maintenance, and caring for your family. These are asked in Part 3.

1. Do you currently have a job or do any unpaid work outside your home?

☐ **Yes**

☐ No → ***Skip to PART 2: TRANSPORTATION***

The next questions are about all the physical activity you did in the **last 7 days** as part of your paid or unpaid work. This does not include traveling to and from work.

2. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, heavy construction, or climbing up stairs **as part of your work**? Think about only those physical activities that you did for at least 10 minutes at a time.

_____ **days per week**

☐ No vigorous job-related physical activity → ***Skip to question 4***

3. How much time did you usually spend on one of those days doing **vigorous** physical activities as part of your work?

_____ **hours per day**
_____ **minutes per day**

4. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads **as part of your work**? Please do not include walking.

_____ **days per week**

☐ No moderate job-related physical activity → ***Skip to question 6***

5. How much time did you usually spend on one of those days doing **moderate** physical activities as

part of your work?

_____ **hours per day**
_____ **minutes per day**

6. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **as part of your work**? Please do not count any walking you did to travel to or from work.

_____ **days per week**

☐ No job-related walking → ***Skip to PART 2: TRANSPORTATION***

7. How much time did you usually spend on one of those days **walking** as part of your work?

_____ **hours per day**
_____ **minutes per day**

PART 2: TRANSPORTATION PHYSICAL ACTIVITY

These questions are about how you traveled from place to place, including to places like work, stores, movies, and so on.

8. During the **last 7 days**, on how many days did you **travel in a motor vehicle** like a train, bus, car, or tram?

_____ **days per week**

☐ No traveling in a motor vehicle → ***Skip to question 10***

9. How much time did you usually spend on one of those days **traveling** in a train, bus, car, tram, or other kind of motor vehicle?

_____ **hours per day**
_____ **minutes per day**

Now think only about the **bicycling** and **walking** you might have done to travel to and from work, to do errands, or to go from place to place.

10. During the **last 7 days**, on how many days did you **bicycle** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐ No bicycling from place to place → ***Skip to question 12***

11. How much time did you usually spend on one of those days to **bicycle** from place to place?

_____ **hours per day**
_____ **minutes per day**

12. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐ No walking from place to place → ***Skip to PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY***

13. How much time did you usually spend on one of those days **walking** from place to place?

_____ **hours per day**
_____ **minutes per day**

PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY

This section is about some of the physical activities you might have done in the **last 7 days** in and around your home, like housework, gardening, yard work, general maintenance work, and caring for your family.

14. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, chopping wood, shoveling snow, or digging **in the garden or yard**?

_____ **days per week**

☐ No vigorous activity in garden or yard → ***Skip to question 16***

15. How much time did you usually spend on one of those days doing **vigorous** physical activities in the garden or yard?

_____ **hours per day**
_____ **minutes per day**

16. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, sweeping, washing windows, and raking **in the garden or yard**?

_____ **days per week**

☐ No moderate activity in garden or yard → ***Skip to question 18***

17. How much time did you usually spend on one of those days doing **moderate** physical activities in the garden or yard?

_____ **hours per day**
_____ **minutes per day**

18. Once again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, washing windows, scrubbing floors and sweeping **inside your home**?

_____ **days per week**

☐ No moderate activity inside home → ***Skip to PART 4: RECREATION, SPORT AND LEISURE-TIME PHYSICAL ACTIVITY***

19. How much time did you usually spend on one of those days doing **moderate** physical activities inside your home?

_____ **hours per day**
_____ **minutes per day**

PART 4: RECREATION, SPORT, AND LEISURE-TIME PHYSICAL ACTIVITY

This section is about all the physical activities that you did in the **last 7 days** solely for recreation, sport, exercise or leisure. Please do not include any activities you have already mentioned.

20. Not counting any walking you have already mentioned, during the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **in your leisure time**?

_____ **days per week**

☐ No walking in leisure time → ***Skip to question 22***

21. How much time did you usually spend on one of those days **walking** in your leisure time?

_____ **hours per day**
_____ **minutes per day**

22. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like aerobics, running, fast bicycling, or fast swimming **in your leisure time**?

_____ **days per week**

☐ No vigorous activity in leisure time → ***Skip to question 24***

23. How much time did you usually spend on one of those days doing **vigorous** physical activities in your leisure time?

_____ **hours per day**
_____ **minutes per day**

24. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like bicycling at a regular pace, swimming at a regular pace, and doubles tennis **in your leisure time**?

_____ **days per week**

☐ No moderate activity in leisure time → ***Skip to PART 5: TIME SPENT SITTING***

25. How much time did you usually spend on one of those days doing **moderate** physical activities in your leisure time?
_____ **hours per day**
_____ **minutes per day**

PART 5: TIME SPENT SITTING

The last questions are about the time you spend sitting while at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading or sitting or lying down to watch television. Do not include any time spent sitting in a motor vehicle that you have already told me about.

26. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekday**?

_____ **hours per day**
_____ **minutes per day**

27. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekend day**?

_____ **hours per day**
_____ **minutes per day**

This is the end of the questionnaire.

Self-Efficacy of Exercise Questionnaire (Benisovich et al. 1998, Benisovich et al. 1998, Marcus et al. 1992)

The following statements look at how confident you are to exercise when other things get in the way. Read the following items and cross the number that best expresses how each item relates to your confidence in exercising.

1. I am under a lot of stress.

1	2	3	4	5
Not at all confident		Moderately confident		Completely confident

2. I am depressed.

1	2	3	4	5
Not at all confident		Moderately confident		Completely confident

3. I am anxious.

1	2	3	4	5
Not at all confident		Moderately confident		Completely confident

4. I feel I don't have the time.

1	2	3	4	5
Not at all confident		Moderately confident		Completely confident

5. I don't feel like it.

1	2	3	4	5
Not at all confident		Moderately confident		Completely confident

6. I am busy.

1	2	3	4	5
Not at all confident		Moderately confident		Completely confident

7. I am alone.

1	2	3	4	5

Not at all confident		Moderately confident		Completely confident

8. I have to exercise alone.

1	2	3	4	5
Not at all confident		Moderately confident		Completely confident

9. My exercise partner decides not to exercise that day.

1	2	3	4	5
Not at all confident		Moderately confident		Completely confident

10. I don't have access to exercise equipment.

1	2	3	4	5
Not at all confident		Moderately confident		Completely confident

11. I am traveling.

1	2	3	4	5
Not at all confident		Moderately confident		Completely confident

12. My gym is closed.

1	2	3	4	5
Not at all confident		Moderately confident		Completely confident

13. My friends don't want me to exercise.

1	2	3	4	5
Not at all confident		Moderately confident		Completely confident

14. My significant other does not want me to exercise.

1	2	3	4	5
Not at all confident		Moderately confident		Completely confident

15. I am spending time with friends or family who do not exercise.

1	2	3	4	5
Not at all confident		Moderately confident		Completely confident

16. It's raining or snowing.

1	2	3	4	5
Not at all confident		Moderately confident		Completely confident

17. It's cold outside.

1	2	3	4	5
Not at all confident		Moderately confident		Completely confident

18. The roads or sidewalks are snowy.

1	2	3	4	5
Not at all confident		Moderately confident		Completely confident

Processes of Change Questionnaire (Nigg et al. 1999)

The following experiences can affect the exercise habits of some people. Think of similar experiences you may be currently having or have had **during the past month**. Then rate how frequently the event occurs by circling the appropriate number in a 5-point scale.

1. **I read articles about exercise in an attempt to learn more about it.**

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

2. **I look for information related to exercise.**

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

3. **I find out about new methods of exercising.**

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

4. **I get upset when I see people who would benefit from exercise but choose not to exercise.**

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

5. **I am afraid of the consequences to my health if I do not exercise.**

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

6. **I get upset when I realize that people I love would have better health if they exercised.**

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

7. **I realize that if I don't exercise regularly, I may get ill and be a burden to others. I think that my exercising regularly will prevent me from being a burden to the healthcare system.**

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

8. **I think that regular exercise plays a role in reducing health care costs.**

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

9. I feel more confident when I exercise regularly.

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

10. I believe that regular exercise will make me a healthier, happier person.

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

11. I feel better about myself when I exercise.

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

12. I have noticed that many people know that exercise is good for them.

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

13. I am aware of more and more people who are making exercise a part of their lives.

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

14. I have noticed that famous people often advertise the fact that they exercise regularly.

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

15. When I feel tired, I make myself exercise anyway because I know I will feel better afterwards.

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

16. Instead of taking a nap after work, I exercise.

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

17. Instead of relaxing by watching TV or eating, I take a walk or exercise.

1	2	3	4	5

Never	Seldom	Occasionally	Often	Repeatedly

18. I have a friend who encourages me to exercise when I don't feel up to it. I have someone who encourages me to exercise.

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

19. My friends encourage me to exercise.

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

20. One of the rewards of regular exercise is that it improves my mood.

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

21. I try to think of exercise as a time to clear my mind as well as a workout for my body.

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

22. If I engage in regular exercise, I find that I get the benefit of having more energy.

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

23. I tell myself that I can keep exercising if I try hard enough.

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

24. I make commitments to exercise.

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

25. I believe that I can exercise regularly.

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

26. I keep a set of exercise clothes conveniently located so I can exercise whenever I get the time.

1	2	3	4	5

Never	Seldom	Occasionally	Often	Repeatedly

27. I use my calendar to schedule my exercise time.

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

28. I make sure I always have a clean set of exercise clothes.

1	2	3	4	5
Never	Seldom	Occasionally	Often	Repeatedly

Exercise Decisional Balance Questionnaire (Nigg et al. 1998)

This section looks at positive and negative aspects of exercise. Read the following items and indicate how important each statement is with respect to your decision to exercise or not to exercise in your leisure time.

If you disagree with a statement and are unsure how to answer, the statement is probably not important to you.

How important are the following opinions in your decision to exercise or not to exercise?

1. I would have more energy for my family and friends if I exercised regularly.

1	2	3	4	5
Not Important	A little bit important	Somewhat important	Quite important	Extremely Important

2. I would feel embarrassed if people saw me exercising.

1	2	3	4	5
Not Important	A little bit important	Somewhat important	Quite important	Extremely Important

3. I would feel less stressed if I exercised regularly.

1	2	3	4	5
Not Important	A little bit important	Somewhat important	Quite important	Extremely Important

4. Exercise prevents me from spending time with my friends.

1	2	3	4	5
Not Important	A little bit important	Somewhat important	Quite important	Extremely Important

5. Exercising puts me in a better mood for the rest of the day.

1	2	3	4	5
Not Important	A little bit important	Somewhat important	Quite important	Extremely Important

6. I feel uncomfortable or embarrassed in exercise clothes.

1	2	3	4	5
Not Important	A little bit important	Somewhat important	Quite important	Extremely Important

7. I would feel more comfortable with my body if exercised regularly.

1	2	3	4	5
Not Important	A little bit important	Somewhat important	Quite important	Extremely Important

8. There is too much I would have to learn to exercise.

1	2	3	4	5
Not Important	A little bit important	Somewhat important	Quite important	Extremely Important

9. Regular exercise would help me have a more positive outlook on life.

1	2	3	4	5
Not Important	A little bit important	Somewhat important	Quite important	Extremely Important

10. Exercise puts an extra burden on my significant other.

1	2	3	4	5
Not Important	A little bit important	Somewhat important	Quite important	Extremely Important

Character Believability Questionnaire

Below are questions of the game that you played followed by an answer to each question. For each of the answers, indicate how well it describes what happened in the game on a scale from "very bad answer" to "very good answer".

1. **Question: Why did the President ask Bill Tyler to take care of you?**
   Answer: Because Bill and you were in the same plane during the UFO encounter.

1	2	3	4
very bad answer	somewhat bad answer	somewhat good answer	very good answer

2. **Question: Besides you, who were the atomic commandos at the BEGINNING of the story?**
   Answer: Bill, David, Tony, and Jonnie.

1	2	3	4
very bad answer	somewhat bad answer	somewhat good answer	very good answer

3. **Question: What was Edwin Blake's nickname?**
   Answer: Doc.

1	2	3	4
very bad answer	somewhat bad answer	somewhat good answer	very good answer

4. **Question: What was Tony, "Gardello the Great", famous for?**
   Answer: Wrestling championship.

1	2	3	4
very bad answer	somewhat bad answer	somewhat good answer	very good answer

5. **Question: Why were you asked to complete missions related to physical activity?**
   Answer: To regain physical strength and recover lost memories.

1	2	3	4
very bad answer	somewhat bad answer	somewhat good answer	very good answer

6. **Question: Why was the White House convinced the flying saucers were real in the BEGINNING of the story?**
   Answer: Because the atomic commandos encountered them on the Moon.

1	2	3	4

very bad answer	somewhat bad answer	somewhat good answer	very good answer

7. **Question: How did the White House find you before you were assigned an atomic commando?**
   Answer: You were discovered on a shore.

1	2	3	4
very bad answer	somewhat bad answer	somewhat good answer	very good answer

8. **Question: How did Bill Tyler manage to find all the other atomic commando candidates?**
   Answer: He used a strange machine to find talents meeting certain criteria.

1	2	3	4
very bad answer	somewhat bad answer	somewhat good answer	very good answer

System Experience Questionnaire

Respondent ID# ___ ___ ___ ___ ___ ___

Date: _____

This section looks at your experience with the program that you used in the past month.

Choose the answer you think best reflects your opinion.

1. **How much did you like using the program?**

1	2	3	4	5
I disliked it very much	I disliked it somewhat	Neutral	I liked it somewhat	I liked it very much

2. **How likely are you to use the program as a way to relax?**

1	2	3	4	5
Extremely unlikely	Unlikely	Neutral	Likely	Extremely likely

3. **How honest do you think you were when reporting your homework progress while you were using the program?**

1	2	3	4	5
Extremely dishonest	Dishonest	Neutral	Honest	Extremely honest

Appendix E: Interview Questions

1. How do you feel about the program that you were enrolled in for the past three weeks?

2. How frequently did you use the system? Why was that?

3. How do you feel about the comic book you read? What would you do differently if the comic book weren't part of the program? (All conditions except Baseline)

4. How do you feel the experience has influenced your life or will influence your life?

5. What will you do differently if you are to continue using the program in the future?

6. What are some memorable moments you could recall when you played the interactive comic? (All conditions except Baseline)

7. How do you feel particularly about the art work in the comic? (All conditions except Baseline)

References

Breaking the Fourth Wall. http://tvtropes.org/pmwiki/pmwiki.php/Main/BreakingTheFourthWall.

Abbott, H. P. 2008. *The Cambridge Introduction to Narrative*, Cambridge University Press.

Ainsworth, B. E., Caspersen, C. J., Matthews, C. E., Mâsse, L. C., Baranowski, T. and Zhu, W. 2012. *Recommendations to Improve the Accuracy of Estimates of Physical Activity Derived from Self Report*. Journal of physical activity & health 9(0 1): S76.

Ajzen, I. 1991. *The Theory of Planned Behavior*. Organizational behavior and human decision processes 50(2): 179-211.

Ajzen, I. and Fishbein, M. 1980. *Understanding Attitudes and Predicting Social Behaviour*.

Albright, G., Goldman, R., Shockley, K. M., McDevitt, F. and Akabas, S. 2012. *Using an Avatar-Based Simulation to Train Families to Motivate Veterans with Post-Deployment Stress to Seek Help at the Va*. GAMES FOR HEALTH: Research, Development, and Clinical Applications 1(1): 21-28.

Alexandre, I. M., Jardim, D. and Lopes, P. F. 2010. *Maths4kids: Telling Stories with Maths*. Proceedings of the Intelligent Narrative Technologies III Workshop: ACM.

Ammerman, A. S., Lindquist, C. H., Lohr, K. N. and Hersey, J. 2002. *The Efficacy of Behavioral Interventions to Modify Dietary Fat and Fruit and Vegetable Intake: A Review of the Evidence*. Preventive Medicine: An International Journal Devoted to Practice and Theory.

Aoki, N., Ohta, S., Okada, T., Oishi, M. and Fukui, T. 2005. *Insulot a Cellular Phone-Based Edutainment Learning Tool for Children with Type 1 Diabetes*. Diabetes care 28(3): 760-760.

Aylett, R. S., Louchart, S., Dias, J., Paiva, A. and Vala, M. 2005. *Fearnot!–an Experiment in Emergent Narrative*. Intelligent Virtual Agents: Springer.

Bandura, A. 1977. *Self-Efficacy: Toward a Unifying Theory of Behavioral Change*. Psychological review 84(2): 191.

Baranowski, T., Abdelsamad, D., Baranowski, J., O'Connor, T. M., Thompson, D., Barnett, A., Cerin, E. and Chen, T. A. 2012. *Impact of an Active Video Game on Healthy Children's Physical Activity*. Pediatrics 129(3): e636-e642.

Baranowski, T., Baranowski, J., Cullen, K. W., Marsh, T., Islam, N., Zakeri, I. and Honess-Morreale, L. 2003. *Squire's Quest!: Dietary Outcome Evaluation of a Multimedia Game*. American journal of preventive medicine 24(1): 52-61.

Baranowski, T., Baranowski, J., Thompson, D., Buday, R., Jago, R., Griffith, M. J., Islam, N., Nguyen, N. and Watson, K. B. 2011. *Video Game Play, Child Diet, and Physical Activity Behavior Change: A Randomized Clinical Trial*. American journal of preventive medicine 40(1): 33-38.

Bartholomew, L., Gold, R., Parcel, G., Czyzewski, D., Sockrider, M., Fernandez, M., Shegog, R. and Swank, P. 2000. *Watch, Discover, Think, and Act: Evaluation of Computer-Assisted Instruction to Improve Asthma Self-Management in Inner-City Children*. Patient education and counseling 39(2): 269-280.

Beale, I., Kato, P., Marin-Bowling, V., Guthrie, N. and Cole, S. 2007. *Improvement in Cancer-Related Knowledge Following Use of a Psychoeducational Video Game for Adolescents and Young Adults with Cancer*. Journal of Adolescent Health 41(3): 263-270.

Benisovich, S., Rossi, J., Norman, G. and Nigg, C. 1998. *Development of a Multidimensional Measure of Exercise Self-Efficacy*. Annals of Behavioral Medicine 20(suppl.).

Benisovich, S., Rossi, J., Norman, G. and Nigg, C. 1998. *A Multidimensional Approach to Exercise Self-Efficacy: Relationship with Exercise Behaviour and Attitudes Towards Exercise*. annual meeting of the New England Psychology Association, Boston, MA.

Bickmore, T., Schulman, D. and Yin, L. 2009. *Engagement Vs. Deceit: Virtual Humans with Human Autobiographies*. IVA 2009: Springer.

Bickmore, T., Schulman, D. and Yin, L. 2010. *Maintaining Engagement in Long-Term Interventions with Relational Agents*. Applied Artificial Intelligence 24(6): 648-666.

Bock, B. C., Marcus, B. H., Pinto, B. M. and Forsyth, L. H. 2001. *Maintenance of Physical Activity Following an Individualized Motivationally Tailored Intervention*. Annals of Behavioral Medicine 23(2): 79-87.

Bogost, I. 2011. *Gamification Is Bullshit*. http://bogost.com/writing/blog/gamification_is_bullshit/.

Brandt, G. W. and Weiss, P. 1998. *Modern Theories of Drama: A Selection of Writings on Drama and Theatre, 1850-1990*, Clarendon Press.

Bringsjord, S. and Ferrucci, D. 1999. *Artificial Intelligence and Literary Creativity: Inside the Mind of Brutus, a Storytelling Machine*, Psychology Press.

Brockmyer, J. H., Fox, C. M., Curtiss, K. A., McBroom, E., Burkhart, K. M. and Pidruzny, J. N. 2009. *The Development of the Game Engagement Questionnaire: A Measure of Engagement in Video Game-Playing*. Journal of Experimental Social Psychology 45(4): 624-634.

Brown, S., Lieberman, D. A., Gemeny, B., Fan, Y., Wilson, D. and Pasta, D. 1997. *Educational Video Game for Juvenile Diabetes: Results of a Controlled Trial*. Informatics for Health and Social Care 22(1): 77-89.

Burns, J. M., Webb, M., Durkin, L. A. and Hickie, I. B. 2010. *Reach out Central: A Serious Game Designed to Engage Young Men to Improve Mental Health and Wellbeing*. Medical Journal of Australia 192(11): S27.

Campbell, J. 2008. *The Hero with a Thousand Faces*, New World Library.

Cantino, A. S., Roberts, D. L. and Isbell, C. L. 2007. *Autonomous Nondeterministic Tour Guides: Improving Quality of Experience with Ttd-Mdps*. Proceedings of the 6th international joint conference on Autonomous agents and multiagent systems: ACM.

Cavazza, M., Charles, F. and Mead, S. J. 2002. *Planning Characters' Behaviour in Interactive Storytelling*. The Journal of Visualization and Computer Animation 13(2): 121-131.

Christian, D. B. and Young, R. M. 2004. *Comparing Cognitive and Computational Models of Narrative Structure*. AAAI.

Clark, M. C. and Rossiter, M. 2008. *Narrative Learning in Adulthood*. New directions for adult and continuing education 2008(119): 61-70.

Cohen, J. 2013. *Statistical Power Analysis for the Behavioral Sciences*, Academic press.

Coyle, D., Doherty, G. and Sharry, J. 2009. *An Evaluation of a Solution Focused Computer Game in Adolescent Interventions*. Clinical Child Psychology and Psychiatry 14(3): 345-360.

CSEP 2002. *Par-Q & You*. Canadian Society for Exercise Physiology.

Duncan, L. R., Hieftje, K. D., Culyba, S. and Fiellin, L. E. 2014. *Game Playbooks: Tools to Guide Multidisciplinary Teams in Developing Videogame-Based Behavior Change Interventions*. Translational Behavioral Medicine 4(1): 108-116.

Durga, S., Hallinan, S., El-Nasr, M.S., Shiyko, M. and Sceppa, C. In Press. *Investigating Behavior Change Indicators and Cognitive*

Measures in Persuasive Health Games. Foundations of Digital Games 2015, Pacific Grove, CA.

Egri, L. 2007. *The Art of Dramatic Writing*, Wildside Pr.

Fairclough, C. R. 2007. *Story Games and the Opiate System*.

Fiellin, L. E., Hieftje, K. D., Fakhouri, T., Duncan, L. R., Sawyer, B. and Fiellin, D. 2015. *Playforward: A Videogame That Increases Drug, Alcohol and Sexual Risk Knowledge in Teens*. Drug & Alcohol Dependence 146: e277-e278.

Figueiredo, R., Dias, J., Paiva, A., Aylett, R. and Louchart, S. 2006. *Shaping Emergent Narratives for a Pedagogical Application*. NILE-Narrative and Interactive Learning Environments: 27-36.

Fishbein, M. and Ajzen, I. 1975. *Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research*.

Fitzgerald, D., Trakarnratanakul, N., Smyth, B. and Caulfield, B. 2010. *Effects of a Wobble Board-Based Therapeutic Exergaming System for Balance Training on Dynamic Postural Stability and Intrinsic Motivation Levels*. journal of orthopaedic & sports physical therapy 40(1): 11-19.

Freeman, D. 2004. *Creating Emotion in Games: The Craft and Art of Emotioneering™*. Computers in Entertainment (CIE) 2(3): 15-15.

Fujiki, Y., Kazakos, K., Puri, C., Buddharaju, P., Pavlidis, I. and Levine, J. 2008. *Neat-O-Games: Blending Physical Activity and Fun in the Daily Routine*. Computers in Entertainment (CIE) 6(2): 21.

Giannatos, S., Cheong, Y.-G., Nelson, M. J. and Yannakakis, G. N. 2012. *Generating Narrative Action Schemas for Suspense*. Proceedings of the Artificial Intelligence and Interactive Digital Entertainment Conference.

Giannatos, S., Nelson, M. J., Cheong, Y.-G. and Yannakakis, G. N. 2011. *Suggesting New Plot Elements for an Interactive Story*. Proceedings of the 4th Workshop on Intelligent Narrative Technologies, AIIDE. AAAI Press.

Glanz, K., Rimer, B. K. and Viswanath, K. 2008. *Health Behavior and Health Education: Theory, Research, and Practice*, Jossey-Bass.

Goran, M. I. and Reynolds, K. 2005. *Interactive Multimedia for Promoting Physical Activity (Impact) in Children*. Obesity research 13(4): 762-771.

Graves, L., Ridgers, N. D., Atkinson, G. and Stratton, G. 2010. *The Effect of Active Video Gaming on Children's Physical Activity, Behavior Preferences and Body Composition*. Pediatric exercise science 22(4): 535.

Graves, L., Stratton, G., Ridgers, N. and Cable, N. 2008. *Energy Expenditure in Adolescents Playing New Generation Computer Games*. British journal of sports medicine 42(7): 592-594.

Greene, K. and LAURA, S. B. 2003. *Messages Influencing College Women's Tanning Bed Use: Statistical Versus Narrative Evidence Format and a Self-Assessment to Increase Perceived Susceptibility*. Journal of Health Communication 8(5): 443-461.

Groh, F. 2012. *Gamification: State of the Art Definition and Utilization*. Institute of Media Informatics Ulm University 39.

Hagströmer, M., Oja, P. and Sjöström, M. 2006. *The International Physical Activity Questionnaire (Ipaq): A Study of Concurrent and Construct Validity*. Public health nutrition 9(06): 755-762.

Haskell, W. L., Lee, I.-M., Pate, R. R., Powell, K. E., Blair, S. N., Franklin, B. A., Macera, C. A., Heath, G. W., Thompson, P. D. and Bauman, A. 2007. *Physical Activity and Public Health: Updated Recommendation for Adults from the American College of Sports Medicine and the American Heart Association*. Circulation 116(9): 1081.

Hawkins, R., Kreuter, M., Resnicow, K., Fishbein, M. and Dijkstra, A. 2008. *Understanding Tailoring in Communicating About Health*. Health education research 23(3): 454.

Heller, M. D., Roots, K., Srivastava, S., Schumann, J., Srivastava, J. and Hale, T. S. 2013. *A Machine Learning-Based Analysis of Game Data for Attention Deficit Hyperactivity Disorder Assessment*. GAMES FOR HEALTH: Research, Development, and Clinical Applications 2(5): 291-298.

Hills, D. 2010. *A Conversational Framework for Emergent Collaborative Storytelling*. Proceedings of the Intelligent Narrative Technologies III Workshop: ACM.

Hinyard, L. J. and Kreuter, M. W. 2007. *Using Narrative Communication as a Tool for Health Behavior Change: A Conceptual, Theoretical, and Empirical Overview*. Health Education & Behavior 34(5): 777-792.

Hochbaum, G. M. 1958. *Public Participation in Medical Screening Programs: A Socio-Psychological Study*, US Department of Health, Education, and Welfare, Public Health Service, Bureau of State Services, Division of Special Health Services, Tuberculosis Program.

Homer, C., Susskind, O., Alpert, H. R., Owusu, C., Schneider, L., Rappaport, L. A. and Rubin, D. H. 2000. *An Evaluation of an Innovative Multimedia Educational Software Program for Asthma Management: Report of a Randomized, Controlled Trial*. Pediatrics 106(Supplement 1): 210-215.

Horswill, I. 2012. *Punch and Judy Ai Playset: A Generative Farce Manifesto Or: The Tragical Comedy or Comical Tragedy of Predicate Calculus*. Eighth Artificial Intelligence and Interactive Digital Entertainment Conference.

Houston, T. K., Allison, J. J., Sussman, M., Horn, W., Holt, C. L., Trobaugh, J., Salas, M., Pisu, M., Cuffee, Y. L. and Larkin, D. 2011. *Culturally Appropriate Storytelling to Improve Blood Pressurea Randomized Trial*. Annals of internal medicine 154(2): 77-84.

Hoysniemi, J. 2006. *International Survey on the Dance Dance Revolution Game*. Computers in Entertainment (CIE) 4(2): 8.

Hunicke, R., LeBlanc, M. and Zubek, R. 2004. *Mda: A Formal Approach to Game Design and Game Research*.

Kato, P. M., Cole, S. W., Bradlyn, A. S. and Pollock, B. H. 2008. *A Video Game Improves Behavioral Outcomes in Adolescents and Young Adults with Cancer: A Randomized Trial*. Pediatrics 122(2): e305-e317.

Kendall, S. B. 1974. *Preference for Intermittent Reinforcement*. Journal of the Experimental Analysis of Behavior 21(3): 463-473.

Kharrazi, H., Lu, A. S., Gharghabi, F. and Coleman, W. 2012. *A Scoping Review of Health Game Research: Past, Present, and Future*. GAMES FOR HEALTH: Research, Development, and Clinical Applications 1(2): 153-164.

King, A., Bickmore, T., T. Campero, I., Pruitt, L. and Yin, L. 2011. *Employing 'Virtual Advisors' to Promote Physical Activity in Underserved Communities: Results from the Compass Study*. Society for Behavioral Medicine (SBM) annual meeting.

Knickmeyer, R. L. and Mateas, M. 2005. *Preliminary Evaluation of the Interactive Drama Facade*. CHI '05 extended abstracts on Human factors in computing ACM.

Krebs, P., Burkhalter, J. E., Snow, B., Fiske, J. and Ostroff, J. S. 2013. *Development and Alpha Testing of Quitit: An Interactive Video Game to Enhance Skills for Coping with Smoking Urges*. JMIR research protocols 2(2).

Kreuter, M. W., Strecher, V. J. and Glassman, B. 1999. *One Size Does Not Fit All: The Case for Tailoring Print Materials*. Annals of Behavioral Medicine 21(4): 276-283.

Lazzaro, N. 2004. *Why We Play Games: Four Keys to More Emotion without Story*.

Lebowitz, M. 1987. *Planning Stories*. Proceedings of the cognitive science society, Hillsdale.

Lee, S. Y., Mott, B. W. and Lester, J. C. 2011. *Modeling Narrative-Centered Tutorial Decision Making in Guided Discovery Learning*. Artificial Intelligence in Education: Springer.

Legler, J., Meissner, H. I., Coyne, C., Breen, N., Chollette, V. and Rimer, B. K. 2002. *The Effectiveness of Interventions to Promote Mammography among Women with Historically Lower Rates of Screening*. Cancer Epidemiology Biomarkers & Prevention 11(1): 59-71.

Li, B., Lee-Urban, S. and Riedl, M. O. 2012. *Toward Autonomous Crowd-Powered Creation of Interactive Narratives*. Proceedings of the 5th AAAI Workshop on Intelligent Narrative Technologies.

Li, B. and Riedl, M. O. 2011. *Creative Gadget Design in Fictions: Generalized Planning in Analogical Spaces*. Proceedings of the 8th ACM conference on Creativity and cognition: ACM.

Lieberman, D. A. 2001. *Management of Chronic Pediatric Diseases with Interactive Health Games: Theory and Research Findings*. The Journal of Ambulatory Care Management 24(1): 26.

Lin, J. J., Mamykina, L., Lindtner, S., Delajoux, G. and Strub, H. B. 2006. *Fish'n'steps: Encouraging Physical Activity with an Interactive Computer Game*. Ubicomp 2006: Ubiquitous Computing, Springer: 261-278.

Loyall, A. B. 1997. *Believable Agents: Building Interactive Personalities*, Mitsubishi Electric Research Laboratories.

Lu, A. S., Baranowski, T., Thompson, D. and Buday, R. 2012. *Story Immersion of Videogames for Youth Health Promotion: A Review of Literature*. GAMES FOR HEALTH: Research, Development, and Clinical Applications 1(3): 199-204.

Lu, A. S., Thompson, D., Baranowski, J., Buday, R. and Baranowski, T. 2012. *Story Immersion in a Health Videogame for Childhood Obesity Prevention*. GAMES FOR HEALTH: Research, Development, and Clinical Applications 1(1): 37-44.

Maddison, R., Foley, L., Mhurchu, C. N., Jiang, Y., Jull, A., Prapavessis, H., Hohepa, M. and Rodgers, A. 2011. *Effects of Active Video Games on Body Composition: A Randomized Controlled Trial*. The American journal of clinical nutrition 94(1): 156-163.

Magerko, B. 2005. *Story Representation and Interactive Drama*. AIIDE.

Magerko, B. and Laird, J. 2003. *Building an Interactive Drama Architecture*. First International Conference on Technologies for Interactive Digital Storytelling and Entertainment.

Magerko, B., Laird, J., Assanie, M., Kerfoot, A. and Stokes, D. 2004. *Ai Characters and Directors for Interactive Computer Games*. Ann Arbor 1001(48): 109-2110.

Magerko, B. and Laird, J. E. 2005. *Mediating the Tension between Plot and Interaction*. Ann Arbor 1001: 48109-42110.

Maloney, A. E., Bethea, T. C., Kelsey, K. S., Marks, J. T., Paez, S., Rosenberg, A. M., Catellier, D. J., Hamer, R. M. and Sikich, L. 2012. *A Pilot of a Video Game (Ddr) to Promote Physical Activity and Decrease Sedentary Screen Time*. Obesity 16(9): 2074-2080.

Mani, I. 2010. *Predicting Reader Response in Narrative*. Proceedings of the Intelligent Narrative Technologies III Workshop: ACM.

Marcus, B., Selby, V., Niaura, R. and Rossi, J. 1992. *Self-Efficacy and the Stages of Exercise Behavior Change*. Research Quarterly for Exercise and Sport 63(1): 60.

Marsella, S., Johnson, W. L. and LaBore, C. 2003. *Interactive Pedagogical Drama for Health Interventions*. 11th International Conference on Artificial Intelligence in Education, Sydney, Australia.

Marsella, S. C., Johnson, W. L. and LaBore, C. 2000. *Interactive Pedagogical Drama*. Proceedings of the fourth international conference on Autonomous agents: ACM.

Masek, M., Hingston, P., Carrigy, M., Collins, L. and Nosaka, K. K. 2009. *Raising Heart Rate with Dance Pad Based Computer Games*.

Mateas, M. 2002. *Interactive Drama, Art and Artificial Intelligence*, Carnegie Mellon University.

McCoy, J., Treanor, M., Samuel, B., Reed, A. A., Wardrip-Fruin, N. and Mateas, M. 2012. *Prom Week*. Proceedings of the International Conference on the Foundations of Digital Games: ACM.

McCoy, J., Treanor, M., Samuel, B., Tearse, B., Mateas, M. and Wardrip-Fruin, N. 2010. *Comme Il Faut 2: A Fully Realized Model for Socially-Oriented Gameplay*. Proceedings of the Intelligent Narrative Technologies III Workshop: ACM.

Meichenbaum, D. and Turk, D. C. 1987. *Facilitating Treatment Adherence: A Practitioner's Guidebook*, Plenum Press.

Merry, S. N., Stasiak, K., Shepherd, M., Frampton, C., Fleming, T. and Lucassen, M. F. 2012. *The Effectiveness of Sparx, a Computerised Self Help Intervention for Adolescents Seeking Help for Depression: Randomised Controlled Non-Inferiority Trial*. BMJ: British Medical Journal 344.

Mhurchu, C. N., Maddison, R., Jiang, Y., Jull, A., Prapavessis, H. and Rodgers, A. 2008. *Couch Potatoes to Jumping Beans: A Pilot Study of the Effect of Active Video Games on Physical Activity in Children*. International Journal of Behavioral Nutrition and Physical Activity 5(1): 8.

Milam, D., El-Nasr, M.S. and Wakkary, R. 2008. *Looking at the Interactive Narrative Experience through the Eyes of the Participants*. Interactive Storytelling: 96-107.

Mokdad, A. H., Marks, J. S., Stroup, D. F. and Gerberding, J. L. 2004. *Actual Causes of Death in the United States, 2000*. Jama 291(10): 1238-1245.

Mokdad, A. H., Marks, J. S., Stroup, D. F. and Gerberding, J. L. 2005. *Correction: Actual Causes of Death in the United States, 2000*. Jama 293(3): 293-294.

Moore, J. B., Pawloski, L. R., Goldberg, P., Kyeung, M. O., Stoehr, A. and Baghi, H. 2009. *Childhood Obesity Study: A Pilot Study of the Effect of the Nutrition Education Program Color My Pyramid*. The Journal of School Nursing 25(3): 230-239.

Mott, B. W. and Lester, J. C. 2006. *U-Director: A Decision-Theoretic Narrative Planning Architecture for Storytelling Environments*. AAMAS: Citeseer.

Murray, J. H. 1997. *Hamlet on the Holodeck: The Future of Narrative in Cyberspace*, SimonandSchuster. com.

Nelson, M. J., Mateas, M., Roberts, D. L. and Isbell, C. L. 2006. *Declarative Optimization-Based Drama Management in Interactive Fiction*. Computer Graphics and Applications, IEEE 26(3): 32-41.

Nelson, M. J., Roberts, D. L., Isbell Jr, C. L. and Mateas, M. 2006. *Reinforcement Learning for Declarative Optimization-Based Drama Management*. Proceedings of the fifth international joint conference on Autonomous agents and multiagent systems: ACM.

Niehaus, J. and Young, R. M. 2010. *A Method for Generating Narrative Discourse to Prompt Inferences*. Proceedings of the Intelligent Narrative Technologies III Workshop: ACM.

Nigg, C., Norman, G., Rossi, J. and Benisovich, S. 1999. *Processes of Exercise Behavior Change: Redeveloping the Scale*. Ann Behav Med 21: 79.

Nigg, C., Rossi, J., Norman, G. and Benisovich, S. 1998. *Structure of Decisional Balance for Exercise Adoption*. Annals of Behavioral Medicine 20: S211.

Noar, S. M., Benac, C. N. and Harris, M. S. 2007. *Does Tailoring Matter? Meta-Analytic Review of Tailored Print Health Behavior Change Interventions*. Psychological Bulletin 133(4): 673.

Norman, G., Benisovich, S., Nigg, C. and Rossi, J. 1998. *Examining Three Exercise Staging Algorithms in Two Samples*. Ann Behav Med 20: S211.

Owens, S. G., Garner III, J. C., Loftin, J. M., van Blerk, N. and Ermin, K. 2011. *Changes in Physical Activity and Fitness after 3 Months of Home Wii Fit™ Use*. The Journal of Strength & Conditioning Research 25(11): 3191.

Pate, R. R., Pratt, M., Blair, S. N., Haskell, W. L., Macera, C. A., Bouchard, C., Buchner, D., Ettinger, W., Heath, G. W. and King, A. C. 1995. *Physical Activity and Public Health: A Recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine*. Jama 273(5): 402-407.

Peng, W. 2009. *Design and Evaluation of a Computer Game to Promote a Healthy Diet for Young Adults*. Health communication 24(2): 115-127.

PÉrez, R. P. Ý. and Sharples, M. 2001. *Mexica: A Computer Model of a Cognitive Account of Creative Writing*. Journal of Experimental & Theoretical Artificial Intelligence 13(2): 119-139.

Pizzi, D. and Cavazza, M. 2007. *Affective Storytelling Based on Characters' Feelings*. Intelligent Narrative Technologies: Papers from the AAAI Fall Symposium.

Polanyi, L., Lakoff, G. and Ross, J. R. 1985. *Telling the American Story: A Structural and Cultural Analysis of Conversational Storytelling*, Ablex Publishers Norwood, NJ.

Prince, G. 2003. *A Dictionary of Narratology*, Bison Books.

Prochaska, J. O., Redding, C. A. and Evers, K. E. 2002. *The Transtheoretical Model and Stages of Change*. Health behavior and health education: Theory, research, and practice 2: 60-84.

Prochaska, J. O. and Velicer, W. F. 1997. *The Transtheoretical Model of Health Behavior Change*. American journal of health promotion 12(1): 38-48.

Prochaska, J. O., Velicer, W. F., Fava, J. L., Rossi, J. S. and Tsoh, J. Y. 2001. *Evaluating a Population-Based Recruitment Approach and a Stage-Based Expert System Intervention for Smoking Cessation*. Addictive behaviors 26(4): 583-602.

Riedl, M., Saretto, C. J. and Young, R. M. 2003. *Managing Interaction between Users and Agents in a Multi-Agent Storytelling Environment*. Proceedings of the second international joint conference on Autonomous agents and multiagent systems: ACM.

Riedl, M. O. 2010. *A Comparison of Interactive Narrative System Approaches Using Human Improvisational Actors*. Proceedings of the intelligent narrative technologies III workshop: ACM.

Riedl, M. O. and Young, R. M. 2005. *An Objective Character Believability Evaluation Procedure for Multi-Agent Story Generation Systems*: Springer.

Riedl, M. O. and Young, R. M. 2006. *From Linear Story Generation to Branching Story Graphs*. Computer Graphics and Applications, IEEE 26(3): 23-31.

Roberts, D. L., Furst, M. L., Dorn, B. and Isbell, C. L. 2009. *Using Influence and Persuasion to Shape Player Experiences*. Proceedings of the 2009 ACM SIGGRAPH Symposium on Video Games: ACM.

Roberts, D. L., Narayanan, H. and Isbell, C. L. 2009. *Learning to Influence Emotional Responses for Interactive Storytelling*. AAAI Spring Symposium: Intelligent Narrative Technologies II.

Roberts, D. L., Nelson, M. J., Isbell, C. L., Mateas, M. and Littman, M. L. 2006. *Targeting Specific Distributions of Trajectories in Mdps*. Proceedings of the National Conference on Artificial Intelligence: Menlo Park, CA; Cambridge, MA; London; AAAI Press; MIT Press; 1999.

Roepke, A. M., Jaffee, S. R., Riffle, O. M., McGonigal, J., Broome, R. and Maxwell, B. *Randomized Controlled Trial of Superbetter, a Smartphone-Based/Internet-Based Self-Help Tool to Reduce Depressive Symptoms*. Games for Health Journal.

Rosenstock, I. M. 1974. *Historical Origins of the Health Belief Model*.

Rubin, D. H., Leventhal, J. M., Sadock, R. T., Letovsky, E., Schottland, P., Clemente, I. and McCarthy, P. 1986. *Educational Intervention by Computer in Childhood Asthma: A Randomized Clinical Trial Testing the Use of a New Teaching Intervention in Childhood Asthma*. Pediatrics 77(1): 1-10.

Scanlon, M., Drescher, D. and Sarkar, K. 2006. *Improvement of Visual Attention through a Web-Based Training Program*. Poster presented at Society for Neurosciences Annual Meeting in Atlanta, GA.

Schroeder, S. A. 2007. *We Can Do Better—Improving the Health of the American People*. New England Journal of Medicine 357(12): 1221-1228.

Schulman, D., Bickmore, T. W. and Sidner, C. L. 2011. *An Intelligent Conversational Agent for Promoting Long-Term Health Behavior Change Using Motivational Interviewing*. AAAI Spring Symposium: AI and Health Communication.

El-Nasr, M.S. 2007. *Interaction, Narrative, and Drama: Creating an Adaptive Interactive Narrative Using Performance Arts Theories*. Interaction Studies 8(2): 209-240.

El-Nasr, M.S., Andres, L., Lavender, T., Funk, N., Jahangiri, N. and Sun, M. 2011. *Igniteplay: Encouraging and Sustaining Healthy Living through Social Games*. Games Innovation Conference (IGIC), 2011 IEEE International: IEEE.

Shoulson, A., Garcia, D. and Badler, N. I. 2011. *Selecting Agents for Narrative Roles*. Intelligent Narrative Technologies.

Silk, K. J., Sherry, J., Winn, B., Keesecker, N., Horodynski, M. A. and Sayir, A. 2008. *Increasing Nutrition Literacy: Testing the Effectiveness of Print, Web Site, and Game Modalities*. Journal of nutrition education and behavior 40(1): 3-10.

Simons, M., de Vet, E., Hoornstra, S., Brug, J., Seidell, J. and Chinapaw, M. 2012. *Adolescents' Views on Active and Non-Active Videogames: A Focus Group Study*. GAMES FOR HEALTH: Research, Development, and Clinical Applications 1(3): 211-218.

Sinclair, J., Hingston, P. and Masek, M. 2007. *Considerations for the Design of Exergames*. Proceedings of the 5th international conference on Computer graphics and interactive techniques in Australia and Southeast Asia: ACM.

Skinner, B. F., Skinner, B. F., Skinner, B. F. and Skinner, B. F. 1972. *Beyond Freedom and Dignity*, Springer.

Slater, M. D., Buller, D. B., Waters, E., Archibeque, M. and LeBlanc, M. 2003. *A Test of Conversational and Testimonial Messages Versus Didactic Presentations of Nutrition Information*. Journal of nutrition education and behavior 35(5): 255-259.

Slater, M. D., Green, M., Strange, J. and Brock, T. 2002. *Entertainment Education and the Persuasive Impact of Narratives*. Narrative impact: Social and cognitive foundations: 157-181.

Slater, M. D. and Rouner, D. 1996. *Value-Affirmative and Value-Protective Processing of Alcohol Education Messages That Include Statistical Evidence or Anecdotes*. Communication Research 23(2): 210-235.

Southard, D. R. and Southard, B. H. 2006. *Promoting Physical Activity in Children with Metakenkoh*. Clinical and investigative medicine. Médecine clinique et experimentale 29(5): 293-297.

Spencer, L., Pagell, F., Hallion, M. E. and Adams, T. B. 2002. *Applying the Transtheoretical Model to Tobacco Cessation and Prevention: A Review of Literature*. American Journal of Health Promotion 17(1): 7-71.

Strecher, V. 2007. *Internet Methods for Delivering Behavioral and Health-Related Interventions (Ehealth)*. Annu. Rev. Clin. Psychol. 3: 53-76.

Sullivan, A., Mateas, M. and Wardrip-Fruin, N. 2010. *Rules of Engagement: Moving Beyond Combat-Based Quests*. Proceedings of the Intelligent Narrative Technologies III Workshop: ACM.

Tanenbaum, J., Tanenbaum, K., El-Nasr, M. S. and Hatala, M. 2010. *Authoring Tangible Interactive Narratives Using Cognitive Hyperlinks*. Proceedings of the Intelligent Narrative Technologies III Workshop: ACM.

Thomas, R., Cahill, J. and Santilli, L. 1997. *Using an Interactive Computer Game to Increase Skill and Self-Efficacy Regarding Safer Sex Negotiation: Field Test Results*. Health Education & Behavior 24(1): 71.

Thomas, S., Reading, J. and Shephard, R. J. 1992. *Revision of the Physical Activity Readiness Questionnaire (Par-Q)*. Canadian journal of sport sciences.

Thue, D., Bulitko, V., Spetch, M. and Wasylishen, E. 2007. *Learning Player Preferences to Inform Delayed Authoring*.

Tomaszewski, Z. 2011. *On the Use of Reincorporation in Interactive Drama*. Intelligent Narrative Technologies.

Tomaszewski, Z. and Adviser-Binsted, K. 2011. *Marlinspike: An Interactive Drama System*.

Tomaszewski, Z. and Binsted, K. 2009. *Demeter: An Implementation of the Marlinspike Interactive Drama System*. AAAI Spring Symposium: Intelligent Narrative Technologies II.

Turner, S. R. 1994. *The Creative Process: A Computer Model of Storytelling and Creativity*, Psychology Press.

Vardoulakis, L. M. 2013. *Social Desirability Bias and Engagement in Systems Designed for Long-Term Health Tracking*, Northeastern University Boston.

Velicer, W. F., Prochaska, J. O., Bellis, J. M., DiClemente, C. C., Rossi, J. S., Fava, J. L. and Steiger, J. H. 1993. *An Expert System Intervention for Smoking Cessation*. Addictive behaviors 18(3): 269-290.

Vogler, C. 1998. *The Writer's Journey: Mythic Structure for Writers*, Michael Wiese Productions Studio City, CA.

Warburton, D. E. R., Bredin, S. S. D., Horita, L. T. L., Zbogar, D., Scott, J. M., Esch, B. T. A. and Rhodes, R. E. 2007. *The Health Benefits of Interactive Video Game Exercise*. Applied Physiology, Nutrition, and Metabolism 32(4): 655-663.

Webb, T., Joseph, J., Yardley, L. and Michie, S. 2010. *Using the Internet to Promote Health Behavior Change: A Systematic Review and Meta-Analysis of the Impact of Theoretical Basis, Use of Behavior Change Techniques, and Mode of Delivery on Efficacy*. Journal of medical Internet research 12(1): e4.

Weinstein, N. D. 1988. *The Precaution Adoption Process*. Health psychology 7(4): 355.

Weinstein, N. D. and Sandman, P. M. 1992. *A Model of the Precaution Adoption Process: Evidence from Home Radon Testing*. Health psychology 11(3): 170.

Weyhrauch, P. and Bates, J. 1997. *Guiding Interactive Drama*, Carnegie Mellon University.

Wobbrock, J. O., Findlater, L., Gergle, D. and Higgins, J. J. 2011. *The Aligned Rank Transform for Nonparametric Factorial Analyses Using Only Anova Procedures*. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems: ACM.

Yach, D., Hawkes, C., Gould, C. L. and Hofman, K. J. 2004. *The Global Burden of Chronic Diseases: Overcoming Impediments to Prevention and Control*. Jama 291(21): 2616-2622.

Yavuzer, G., Senel, A., Atay, M. and Stam, H. 2008. *''Playstation Eyetoy Games''Improve Upper Extremity-Related Motor Functioning in Subacute Stroke: A Randomized Controlled Clinical Trial*. European journal of physical and rehabilitation medicine 44(3): 237-244.

Yin, L., Ring, L. and Bickmore, T. 2012. *Using an Interactive Visual Novel to Promote Patient Empowerment through Engagement*. Proceedings of the International Conference on the Foundations of Digital Games: ACM.

Yoon, S. L. and Godwin, A. 2006. *Enhancing Self-Management in Children with Sickle Cell Disease through Playing a Cd-Rom Educational Game: A Pilot Study*. Pediatric nursing 33(1): 60-63, 72.

Young, R. M. 1999. *Notes on the Use of Plan Structures in the Creation of Interactive Plot*. AAAI Fall Symposium on Narrative Intelligence.

Young, R. M. 2001. *An Overview of the Mimesis Architecture: Integrating Intelligent Narrative Control into an Existing Gaming Environment*.

Young, R. M., Pollack, M. E. and Moore, J. D. 1994. *Decomposition and Causality in Partial-Order Planning*. AIPS.

Young, R. M. and Riedl, M. 2003. *Towards an Architecture for Intelligent Control of Narrative in Interactive Virtual Worlds*. Proceedings of the 8th international conference on Intelligent user interfaces: ACM.

Young, R. M., Riedl, M. O., Branly, M., Jhala, A., Martin, R. and Saretto, C. 2004. *An Architecture for Integrating Plan-Based Behavior Generation with Interactive Game Environments*. Journal of Game Development 1(1): 51-70.