

Winter 3-15-2017

## **SUPPORTING THERAPY-CENTERED GAME DESIGN FOR BRAIN INJURY REHABILITATION**

Jinghui Cheng  
*DePaul University*, [jinghuicheng@gmail.com](mailto:jinghuicheng@gmail.com)

Follow this and additional works at: [https://via.library.depaul.edu/cdm\\_etd](https://via.library.depaul.edu/cdm_etd)



Part of the [Computer Engineering Commons](#), and the [Other Social and Behavioral Sciences Commons](#)

---

### **Recommended Citation**

Cheng, Jinghui, "SUPPORTING THERAPY-CENTERED GAME DESIGN FOR BRAIN INJURY REHABILITATION" (2017). *College of Computing and Digital Media Dissertations*. 14.  
[https://via.library.depaul.edu/cdm\\_etd/14](https://via.library.depaul.edu/cdm_etd/14)

This Dissertation is brought to you for free and open access by the College of Computing and Digital Media at Via Sapientiae. It has been accepted for inclusion in College of Computing and Digital Media Dissertations by an authorized administrator of Via Sapientiae. For more information, please contact [digitalservices@depaul.edu](mailto:digitalservices@depaul.edu).

SUPPORTING THERAPY-CENTERED GAME DESIGN FOR  
BRAIN INJURY REHABILITATION

BY

JINGHUI CHENG

A DISSERTATION SUBMITTED TO THE SCHOOL OF COMPUTING, COLLEGE  
OF COMPUTING AND DIGITAL MEDIA OF DEPAUL UNIVERSITY  
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF  
DOCTOR OF PHILOSOPHY

DEPAUL UNIVERSITY

CHICAGO, ILLINOIS

2016

DePaul University

College of Computing and Digital Media

Dissertation Defense Report

I have read the dissertation written by:  
Name Jinghui Cheng

SSN \_\_\_\_\_

(To the advisor): The following dissertation title is identical to the one on the title page of the draft returned to the student. This title is approved by me and it is to be used when the final copies of the dissertation are prepared.

Title of dissertation:

SUPPORTING THERAPY-CENTERED GAME DESIGN FOR BRAIN INJURY REHABILITATION

Advisor's Initials \_\_\_\_\_


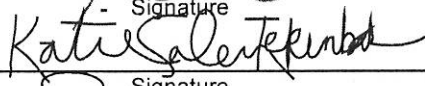
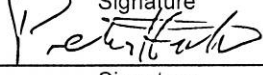

Acceptable. Candidate may proceed to make final copies

Pass, with revisions stated below:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Not Acceptable. Please explain:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Cynthia Putnam		12/22/2016
Advisor (Print Name)	Signature	Date
Katie Salen Tekinbas		1/17/2017
1 <sup>st</sup> Reader (Print Name)	Signature	Date
Peter Hastings		2/14/2017
2 <sup>nd</sup> Reader (Print Name)	Signature	Date
Jinjuan Feng		2/23/2017
3 <sup>rd</sup> Reader (Print Name)	Signature	Date
4 <sup>th</sup> Reader (Print Name)	Signature	Date

SUPPORTING THERAPY-CENTERED GAME DESIGN FOR  
BRAIN INJURY REHABILITATION

ABSTRACT

Brain injuries (BI) are a major public health issue. Many therapists who work with patients who have had a BI include games to ameliorate boredom associated with repetitive rehabilitation. However, designing effective, appropriate, and engaging games for BI therapy is challenging. The challenge is especially manifested when considering how to consolidate the different mindsets and motivations among key stakeholders; i.e., game designers and therapists. In this dissertation, I investigated the ideation, creation, and evaluation of game design patterns and a design tool, GaPBIT (**G**ame Design **P**atterns for **BI** Therapy) that leveraged patterns to support ideation of BI therapy game concepts and facilitate communication among designers and therapists. Design patterns, originated from the work of Christopher Alexander, provide a common design language in a specific field by documenting reusable design concepts that have successfully solved recurring problems.

This investigation involved four overlapping phases. In *Phase One*, I interviewed 11 professional game designers focused on games for health (serious games embedded with health-related goals) to explore how they perceived and

approached their work. In *Phase Two*, I identified 25 therapy-centered game design patterns through analyzing data about game use in BI therapy. Based on those patterns, in *Phase Three* I created and iterated the GaPBIT prototype through user studies. In *Phase Four*, I conducted quasi-experimental case studies to establish the efficacy and user experience of GaPBIT in game design workshops that involved both game designers and therapists.

During the design workshops, the design patterns and GaPBIT supported exploration of game design ideas and effectively facilitated discussion among designers and therapists. The results also indicated that these tools were especially beneficial for novice game designers. This work significantly promotes game design for BI rehabilitation by providing designers and therapists with easier access to the information about requirements in rehabilitation games.

Additionally, this work modeled a novel research methodology for investigating domains where balancing the role of designers and other stakeholders is particularly important. Through a “practitioner-centered” process, this work also provides an exemplar of investigating technologies that directly address the information needs of professional practitioners.

## ACKNOWLEDGEMENTS

Thanks so much to my advisor Dr. Cynthia Putnam, who has provided generous support, valuable advice, and great encouragement in various aspects of my PhD study, including this dissertation. I also received significant input and valuable feedback from Dr. Katie Salen, Dr. Peter Hastings, and Dr. Jinjuan Feng, who served on my dissertation committee. I gratefully acknowledge the financial support that I have received while working on this dissertation from the College of Computing and Digital Media and Professors Cynthia Putnam and Jane Cleland-Huang. Also thanks to my peer PhD students at the department for creating such a friendly and stimulating environment.

Many people have provided practical support in this project. I would like to give special thanks to Dr. Doris Rusch, who helped tremendously in recruiting and provided insightful input that guided the study protocol. Dorian Anderson also provided very much needed support during the workshop sessions.

Thanks to all my participants, without whom this work would not have been possible. I regret that I could not fully acknowledge them by names.

Finally, I am deeply grateful for the love, encouragement, and tolerance of my wife, Jin, who also proved to be a wonderful colleague. And to our son, Liam, who always inspires me with a playful spirit.

## TABLE OF CONTENTS

ABSTRACT.....	iii
ACKNOWLEDGEMENTS.....	v
LIST OF TABLES.....	ix
LIST OF FIGURES.....	x
INTRODUCTION.....	1
CHAPTER 1. THEORETICAL FRAMEWORK.....	6
1.1 Theories About Game Structure.....	6
1.2 Theories About Player Experience.....	13
1.3 Theories About Game Design Practice.....	21
1.4 Summary.....	25
CHAPTER 2. BACKGROUND AND RELATED LITERATURE.....	28
2.1 Brain Injuries.....	28
2.2 Games for Brain Injury Therapy.....	29
2.3 Game Design Patterns.....	32
2.4 Game Design Tools.....	35
2.5 Summary.....	36
CHAPTER 3. PRELIMINARY WORK: UNDERSTANDING GAME USE IN BRAIN INJURY THERAPY.....	38
3.1 Interviews with Therapists About Game Use.....	38
3.2 Observations of Game Therapy Sessions.....	40
3.3 Constructing a Game Therapy Case Base.....	41
3.4 Summary.....	47

CHAPTER 4. PHASE ONE: UNDERSTANDING DESIGNERS OF GAMES FOR HEALTH.....	48
4.1 Methods.....	49
4.2 Findings .....	52
4.3 Discussion.....	68
4.4 Conclusions.....	73
CHAPTER 5. PHASE TWO: IDENTIFYING BRAIN INJURY THERAPY GAME DESIGN PATTERNS.....	74
5.1 Methods for Discovering Game Design Patterns.....	74
5.2 Patterns Overview.....	78
5.3 Early User Feedback on the Game Design Patterns .....	82
5.4 Discussion and Conclusions .....	84
CHAPTER 6. PHASE THREE: CREATING GAPBIT, A DESIGN TOOL FOR BI THERAPY GAMES .....	87
6.1 GaPBIT Interaction Design.....	87
6.2 Usability Study Methods .....	88
6.3 User Feedback and Design Iteration.....	90
6.4 Conclusions.....	94
CHAPTER 7. PHASE FOUR: EVALUATING GAPBIT IN GAME DESIGN WORKSHOPS.....	95
7.1 Methods.....	95
7.2 Game Ideas Created .....	98
7.3 Game Idea Evaluation Results.....	101
7.4 Game Design Workshop Sessions Summary.....	104
7.5 Game Design Workshop Session Details .....	113
7.6 Conclusions and Discussion .....	133



CHAPTER 8. CONCLUSIONS .....	136
8.1 The Four Phases of Research .....	136
8.2 Contributions .....	139
8.3 Future Research Directions.....	140
APPENDIX A. EFFICACY-CENTERED GAME DESIGN PATTERNS.....	143
APPENDIX B. EXPERIENCE-CENTERED GAME DESIGN PATTERNS...	168
APPENDIX C. DESIGNER INTERVIEW RESEARCH MATERIALS .....	187
APPENDIX D. USABILITY STUDY RESEARCH MATERIALS.....	192
APPENDIX E. GAME DESIGN WORKSHOP RESEARCH MATERIALS...	197
APPENDIX F. GAME EVALUATION RESEARCH MATERIALS .....	203
APPENDIX G. DESIGNER INTERVIEW CODEBOOK.....	208
APPENDIX H. GAME THERAPY SESSION OBSERVATION CODEBOOK .....	223
APPENDIX I. GAME DESIGN WORKSHOP CODEBOOK .....	228
BIBLIOGRAPHY.....	237

## LIST OF TABLES

Table 1. Player immersion stages .....	17
Table 2. Summary of interview participants' professional experiences .....	50
Table 3. Game design workshop experimental design .....	97
Table 4. Foci of criteria for evaluating the game pitches .....	98

## LIST OF FIGURES

Figure 1. Flow as an autotelic experience.....	14
Figure 2. Summary of major games user research methods, adopted from Mandryk (2008) .....	25
Figure 3. Designer-Game-Player triad in game design.....	26
Figure 4. Summary attributes of a case.....	42
Figure 5. Final version of the paper-based diary form (page 1) .....	44
Figure 6. Final version of the paper-based diary form (page 2) .....	45
Figure 7. Method for identifying efficacy-centered patterns .....	77
Figure 8. Method for discovering experience-centered patterns .....	78
Figure 9. Summary of the BI therapy game design patterns.....	79
Figure 10. Example user interaction paths in the detailed pattern information page .....	89
Figure 11. Enhancing navigation in detailed pattern info page .....	91
Figure 12. Revised background information structure .....	92
Figure 13. “My Saved Patterns” function.....	93
Figure 14. Average overall score for each game idea.....	102
Figure 15. Therapists’ evaluation of the game ideas on the five criteria focusing on efficacy and appropriateness.....	103
Figure 16. Game designers’ evaluation of the game ideas on the six criteria focusing on player experience outcomes .....	104
Figure 17. Total time spent in each design workshop session.....	105
Figure 18. Percentage of time spent on major activities.....	105
Figure 19. Counts of designer and therapist discussion events .....	106
Figure 20. Percentage of time participants from each case spent on the game design phases .....	110

Figure 21. Frequency of GaPBIT use by phase. Each vertical bar indicates a time slot in which GaPBIT is used.....	112
Figure 22. Major activities of participants from <i>Case PD+T</i> .....	114
Figure 23. Discussion topics between participants from <i>Case PD+T</i> .....	114
Figure 24. Notes taken by the designer from <i>Case PD+T</i> .....	117
Figure 25. Major activities of participants from <i>Case SD+T</i> .....	119
Figure 26. Discussion topics between participants from <i>Case SD+T</i> .....	119
Figure 27. Major activities of participants from <i>Case PD+G</i> .....	122
Figure 28. Notes about game design patterns taken during the elaboration phase of <i>Case PD+G</i> .....	123
Figure 29. Major activities of participants from <i>Case SD+G</i> .....	124
Figure 30. The game designer from <i>Case SD+G</i> imitated patient impairment..	125
Figure 31. Sketch and notes created by the designer in <i>Case SD+G</i> .....	126
Figure 32. Major activities of participants from <i>Case PD+T+G</i> .....	128
Figure 33. Discussion topics between participants from <i>Case PD+T+G</i> .....	128
Figure 34. Designer's sketch of the game's controller from <i>Case PD+T+G</i> .....	130
Figure 35. Major activities of participants from <i>Case SD+T+G</i> .....	131
Figure 36. Discussion topics between participants from <i>Case SD+T+G</i> .....	131
Figure 37. Notes taken by the designer in <i>Case SD+T+G</i> .....	133
Figure 38. Interrelationship among efficacy-centered patterns.....	143
Figure 39. Interrelationship among experience-centered patterns.....	168

## INTRODUCTION

Brain injuries (BI) are a major public health issue affecting many societies worldwide [146]; approximately 6.4 million children and adults in the United States live with a lifelong disability as a result of a BI [154]. Depending on the causes and nature, a BI can result in impairments affecting both physical and cognitive abilities, which in turn, leads to diverse recovery paths. As a result, therapists need to customize rehabilitation treatments to meet each patient's individual needs and unique goals. Many BI rehabilitation treatments require repetitive activities to reinforce practice and learning; it can be challenging to maintain motivation and engagement of patients throughout repetitive rehabilitation exercises [17, 73, 74].

To overcome this challenge, many therapists include games in their therapy sessions. Therapists use varied combinations of commercial off-the-shelf (COTS) games designed for the general public and games that are specifically designed for BI therapy [7]; choices of game use are influenced by budget and game availability. However, currently available games have many limitations for this population. First, COTS games are often too difficult and have too steep a challenge ramp for many who have had a BI [113, 155]; second, games designed specially for rehabilitation have often failed to achieve a good balance between player experience and therapeutic efficacy [28, 185]. Consequently, designing effective, appropriate, and engaging games for BI therapy is a challenging and important area for exploration.

**In this dissertation, I am focused on exploring conceptual and information tools to support the design of therapy-centered games for BI rehabilitation.** In particular, I investigated how a game design tool that leveraged design patterns could promote ideation of BI therapy games and facilitate collaboration among designers and therapists in a serious game design process. Design patterns, originated from Christopher Alexander's work in architecture [5], document reusable design concepts that have successfully solved recurring problems in a specific realm.

In the context of serious games (games designed to support a purposeful goal in addition to entertainment), design patterns have been advocated as an effective tool to support design ideation and facilitate communication among game designers and other stakeholders [78, 102, 125]. As such, game design patterns can play an important role in informing and promoting therapy-centered game design. However, only a few researchers have investigated design patterns for rehabilitation games [78]. There has been little work specifically addressed BI therapy game design patterns. **The first objective of this project was to identify and evaluate game design patterns that focused specifically on design of games for BI rehabilitation.** The BI therapy game design patterns were generated from analysis of data that we (myself and Dr. Cynthia Putnam) gathered in previous projects that focused on the use of COTS games in BI therapy; I then refined the patterns through evaluation studies with professional game designers.

Design patterns alone do not ensure good design. Research has indicated that presenting patterns so that they facilitate pattern choosing and context awareness can greatly promote the efficacy of the use of patterns [86, 99, 189]. In a further complication for this study, game designers of BI rehabilitation games need to consider other factors such as patients' abilities, preferences, and context

of use (e.g. a rehabilitation gym that is shared by many therapists and patients) in order to design appropriate games for target users. However, there are currently no guidelines or tools available to help game designers understand the needs of therapists, their patients, and the multiple parameters that should be considered in the design of therapy-centered games. **The second objective of this work was to create and evaluate a design tool that leveraged the BI therapy game design patterns (created in objective one) that can facilitate collaboration among game designers and therapists.** Following a user-centered approach, I created a prototype web-based tool GaPBIT (**G**ame **D**esign **P**atterns for **BI** **T**herapy). I examined the user experience and efficacy of the prototype in quasi-experimental design workshops that involved both game designers and therapists.

This investigation was comprised of four overlapping phases:

To establish the foundation for this investigation, in *Phase One*, I interviewed 11 professional game designers focused on games for health (serious games embedded with health-related goals) to explore how they perceived and approached their work. This group of game designers (including designers for BI therapy games) focused on particularly challenging design problems that were not well represented in the literature. Through this study, I aimed to pinpoint the challenges they meet in their work and explore the context and requirements for the BI therapy game design patterns and design tools.

In *Phase Two*, I focused on identification of game design patterns through analysis of data we gathered in previous work about game use in BI therapy. Particularly, I explored two types of design patterns: (1) *efficacy-centered* patterns, which focused on enforcing the effectiveness of games at addressing BI therapy goals; and (2) *experience-centered* patterns, which focused on fostering in-game experience of patients who have had a BI. Additionally, I conducted user

studies to evaluate and iterate the design patterns with professional game designers.

In *Phase Three*, I created a design tool prototype, GaPBIT, following a user-centered approach. The initial user interface for GaPBIT was based on the structure of the BI therapy game design patterns. I then evaluated and iterated several versions of interface prototypes through usability studies with six professional game designers.

In *Phase Four*, I conducted quasi-experimental case studies to establish the efficacy and user experience of GaPBIT in game design workshops that involved both game designers and therapists. Through these case studies, I explored how the GaPBIT prototype could facilitate collaboration among designers and therapists and especially support novice designers in creating games for BI therapy.

In sum, this investigation follows a user-centered approach in exploring the creation and evaluation of game design patterns and a game design tool to support creation of games for BI therapy. People who have had a BI represent a diverse population that has wide-ranging physical and cognitive conditions and therapy needs. As such, findings and exemplar set in this project would directly inform other areas of serious games addressing health conditions that require therapy (e.g., cerebral palsy, Alzheimer's disease).

The remainder of this dissertation is organized as follows:

Chapter 1 presents the theoretical framework guiding this investigation.

Chapter 2 provides background information and related research about the use and creation of games for BI therapy, as well as game design patterns and design tools.



Chapter 3 summarizes a preliminary work led by Cynthia Putnam about understanding game use in BI therapy sessions. This previous work has directly contributed to this investigation.

Chapter 4 through Chapter 7 focus on the four research phases of this investigation:

- Chapter 4 describes methods and findings from the game designer interviews that focused on understanding their values and practices when designing games for health.
- Chapter 5 details the process to discover the BI therapy game design patterns, provides an overview of the patterns, and explores initial user feedbacks.
- Chapter 6 introduces the GaPBIT game design tool prototype and discusses the user-centered approach in creating the prototype.
- Chapter 7 describes the methods and findings from the quasi-experimental evaluation studies aimed at establishing efficacy and user experience of the GaPBIT prototype.

In Chapter 8, I conclude this dissertation by summarizing major findings and takeaways and discuss possible future work.

## CHAPTER 1. THEORETICAL FRAMEWORK

This investigation is framed by several categories of theories and frameworks focused on understanding (a) game structure, (b) player experience, and (c) game design practices. Related to *game structure*, elements in definitions of game and gameplay describe fundamental qualities that games for BI therapy should possess; theories about gameplay attributes and player differences specify high-level considerations about game design and analysis; and the concept of meaningful play provides a pragmatic guide for the design and evaluation of games in general, and games for BI therapy specifically. Additionally, research focused on theories about *player experiences* such as game flow, immersion, and motivation uncovers the underlying principles that designers consider when creating games. Research on *game design practices* aims to understand design practitioners and explore games user research methods to provide further guidance on establishing how game designers think and work in practice. In this chapter, I discuss each topic with an emphasis on how they guided this dissertation research.

### 1.1 Theories About Game Structure

I discuss three major theories and constructs associated with the game structure: (1) the definitions of game and gameplay, (2) gameplay attributes and player differences, and (3) the concept of meaningful play.

### 1.1.1 Definitions of Game and Gameplay

Many scholars, researchers, and game design practitioners have provided definitions of game and gameplay. The aim of this discussion is not to identify the “true” definition but to explore concepts that are crucial for the design of serious games, especially games for BI therapy. As one of the early attempts, Johan Huizinga ideated gameplay as a fundamental constituent of ritual and culture and provided the following definition:

*[Play is] a free activity standing quite consciously outside “ordinary” life as being “not serious” but at the same time absorbing the player intensely and utterly. It is an activity connected with no material interest, and no profit can be gained by it. It proceeds within its own proper boundaries of time and space according to fixed rules and in an orderly manner. It promotes the formation of social groupings that tend to surround themselves with secrecy and to stress the difference from the common world by disguise or other means. [85]*

In essence, this definition highlighted several characteristics of gameplay: it is self-contained, intrinsically engaging, bounded by rules, and based on voluntary intentions. In addition, there is no material outcome of play but it has profound social and cultural meaning. Three points in this definition are especially worth noting when considering games for BI rehabilitation. First, gameplay should be intrinsically engaging and have the ability to “absorb” the player. According to this definition, games need to deeply engage their players in order to facilitate play. Second, gameplay happens in self-contained systems and is different from the “ordinary” life. As such, one attribute of gameplay is it encourages players to engage in activities that they would not be willing or able to do otherwise; in other words, gameplay provides a space that could ameliorate the

trust and/or safety concerns shared by patients with a BI. Gameplay in this sense could also: (1) enable players to perform activities (e.g. soccer) they enjoy prior BI but would not be able to do after BI because of a disability and (2) allow players to practice activities (e.g. shopping) that are difficult to perform otherwise. Third, gameplay has profound social meanings that extend the game itself. For example, players could establish and/or foster friendship through playing multiplayer games. Thus, gameplay has the potential to help people who have had a BI to connect with others.

Bernard Suits was among the first who directly tackled the definition of gameplay through a rigid philosophical inquiry. He provided the following definition of gameplay:

*To play a game is to attempt to achieve a specific state of affairs [prelusory goal], using only means permitted by rules [lusory means], where the rules prohibit use of more efficient in favour of less efficient means [constitutive rules], and where the rules are accepted just because they make possible such activity [lusory attitude]. [180]*

Or in short:

*Playing a game is the voluntary attempt to overcome unnecessary obstacles. [180]*

Among other things, this definition emphasized two attributes of game and gameplay: (1) game rules pose “unnecessary” challenges to the players and (2) game players accept these rules and enter the state of gameplay based on a voluntary attitude (i.e. “lusory attitude” in Suits’ terms). In the area of games for rehabilitation, players usually face *unavoidable* obstacles in real life because of

disabilities. Therefore, a game's ability to encourage a "lusory attitude" and inspire them to engage in the *unnecessary* challenges becomes a key to the success of the game. In addition, players' personality and background may affect their tendency to hold a "lusory attitude". So this definition also suggests that player differences are inherently embedded in game design considerations; a game for one may not be a game for another (see section 1.1.2 for discussion of player differences).

Following these first steps, many contemporary game design researchers and practitioners have expanded the definition of games. Considering games as formal systems, Salen and Zimmerman (2004) defined game as "*a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome*" [165]. Focusing on the interaction between player and the game, the player and the world, Juul (2005) proposed that "*a game is a rule-based system with a variable and quantifiable outcome, where different outcomes are assigned different values, the player exerts effort in order to influence the outcome, the player feels emotionally attached to the outcome, and the consequences of the activity are optional and negotiable*" [98]. Schell (2008) claimed that a game is "*a problem-solving activity, approached with a playful attitude*" [167]. Common elements mentioned in many definitions are not only about the structure of games (e.g. rules and goals) but also about the player's attitude (i.e. lusory or playful attitude) and/or experience (e.g. absorbed, engaged, and emotionally attached) in play.

### 1.1.2 Gameplay Attributes and Player Differences

People enjoy different types of games. Researchers have provided models to capture different gameplay types and player differences on game preferences and gameplay behaviors. Caillios (1961) proposed an influential gameplay

classification scheme that categorized game and play into four groups based on the dominant characteristics: *agôn* that involves competition, *alea* that is based on chance, *mimicry* that embraces make-believe, and *ilinx* that takes in sensory stimulation. He further placed all four groups on a continuum between two poles: *paidia* that denotes free play and *ludus* that signifies plays involving rigid rules [34]. This classification elegantly covered a wide range of broad types of gameplay.

Through gameplay observations, Lazzaro (2004) proposed the “four fun keys” to capture players’ emotional attachment to the games: (1) *hard fun*, which is associated with problem solving and a sense of triumph over challenges (i.e. *fero*); (2) *easy fun*, which relates to exploration and features an emotion of curiosity; (3) *serious fun*, which values the games as “altered states” and a channel for relaxation and refreshment; and (4) *people fun*, which emphasizes social interactions that games support through competition and/or teamwork [191].

Extending this model, Bateman and his colleagues at International Hobo Ltd. conducted survey-based research that explored relationships among players’ gaming preferences and the Myers-Briggs temperament types [13]. They identified four types of players: (1) *conquerors*, who play for winning and “beating the game;” (2) *managers*, who value mastery of the game; (3) *wanderers*, who seek for enjoyment or a unique experience in play; and (4) *participants*, who enjoy collaboration in play [13]. Each of the four types included a “hardcore” (i.e. players who spend considerable time playing games and enjoy challenges and conflicts) and a “casual” sub-cluster (i.e. players who enjoy games in a relaxed manner). Their findings indicated a rich diversity that was not recognized by the stereotypical view of game players.

Related, Stuart Brown has studied the effects of play to people's lives through a series of interview-based studies that explore the participants' "play histories." From these studies Brown and Vaughan (2009) distilled eight play personality types: (1) *joker* whose sense of play involves nonsense; (2) *kinesthete* who enjoys movement; (3) *explorer* who enjoys new experiences; (4) *competitor* who enjoys playing to win; (5) *director* who enjoys organizing and planning; (6) *collector* who enjoys gathering objects or experiences; (7) *artist/creator* who enjoys making things; and (8) *storyteller* who values imagination and make-believe in play [25].

This discussion of gameplay attributes and player differences can provide insights into the design of games for BI rehabilitation in two ways; both affect how I approached the game design patterns and the design tool. First, players of rehabilitation games are often quite different from the common game player population. BI patients, typically older than 60 years old, belong to a different age group than the average game players (average age: 35 years old [65]); additionally, they may have health conditions or special needs that can affect their gaming preferences and behaviors. Second, it is important to note that when considering players of a determined patient population, player differences exist; i.e. player personality and previous experience can also contribute to differences in gaming preferences and behaviors.

### 1.1.3 Meaningful Play

In their influential book *Rules of Play*, Salen and Zimmerman (2004) examined a large set of theories and schemas used to analyze game and play. Through this investigation they introduced *meaningful play*, a common construct that grounded many frameworks for game design and studies. Descriptively, they defined meaningful play as the following:

*Meaningful play in a game emerges from the relationship between player action and system outcome; it is the process by which a player takes action within the designed system of a game and the system responds to the action. The meaning of an action in a game resides in the relationship between action and outcome. [165]*

They further depicted meaningful play as a tool to evaluate the quality of game design:

*Meaningful play is what occurs when the relationships between actions and outcomes in a game are both discernable and integrated into the larger context of the game. Creating meaningful play is the goal of successful game design. [165]*

In this sense, meaningful play relies on two important characteristics about the interaction between players and games. First, this interaction needs to be discernable; i.e. the outcomes of player actions need to be presented in a perceptible way to the player. Using games user research terminologies (see section 1.3.3), this characteristic contributes to the *usability* of the game; game usability is the quality attribute of the game that enables players to understand and perform what is needed to play a game [140]. Second, all action-outcome pairs in a game needs to be interconnected to generate an integrated game system. This integration would lead to a complete player experience that is usually associated with clear goals, immediate and relevant feedback, and a sense of progress.

As an important concept that connects game usability and player experience, meaningful play provides valuable insights into game design and evaluation. Researchers have leveraged this concept in the design of games for BI rehabilitation [31, 32, 64]. For example, Burke et al. (2009) considered meaningful play as one of the two principles of game design that “have particular



relevance to rehabilitation;” the other principle was focused on challenge and flow (see section 1.2) [31].

## 1.2 Theories About Player Experience

Player experience (PX), or rather positive PX such as fun and engagement, is at the core of gameplay and is a major focus of contemporary game design. As such, the design and evaluation of games for health (including games for BI rehabilitation) need to consider PX in order to take full advantage of this new medium. Terms that are used to describe positive PX in literature ranged from those as general as fun [28, 108] and enjoyment [128] to those as specific as flow [46, 47] and immersion [95]. In this section, I discuss theories about three major constructs that are usually used to describe positive player experiences in games: (1) flow, (2) immersion, and (3) motivation.

### 1.2.1 The Flow Theory

The research of the psychological concept of flow dates back to the 1960s when Mihaly Csikszentmihalyi and his colleagues explored the optimal experience in creative activities and people’s daily lives [47]. The term *Flow* emerged from participants’ metaphorical descriptions of their best moments and experiences. Csikszentmihalyi identified that the key element of a flow experience is that doing the activity itself becomes its sole purpose and meaning; he named it an *autotelic* experience [46]. Recognizing that most activities have both autotelic and exoteric (i.e. doing the activity for external reasons) aspects, Csikszentmihalyi emphasized the importance of people’s effort and ability to take control over self-consciousness and focus on the autotelic parts to achieve flow [46]. I summarize this aspect of the flow theory in Figure 1.

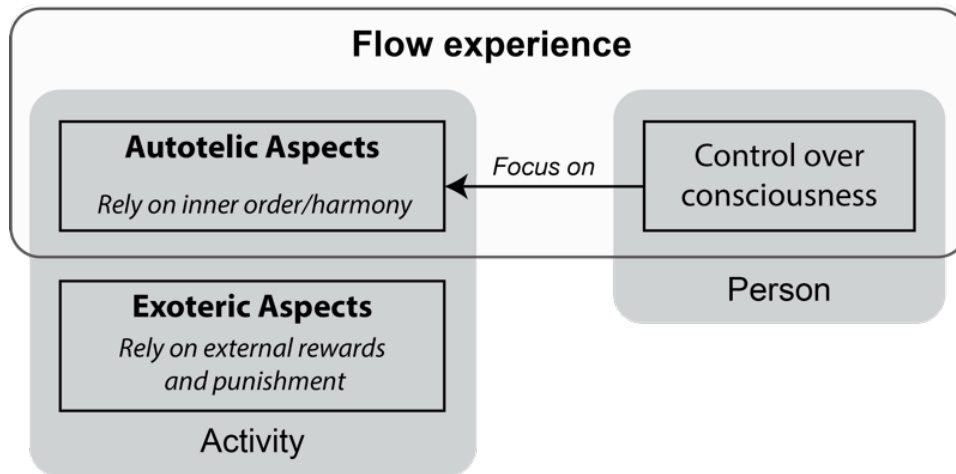


Figure 1. Flow as an autotelic experience

The experience of flow relies not only on the person’s psychological disposition, but also on the characteristics of the activity itself. According to Csikszentmihalyi (1997), flow tends to occur when (1) a person faces a clear set of goals, (2) the activities provide immediate feedback, and (3) there is a balance between the challenge of the activity and the person’s skills [47]. These are the external conditions of the flow experience. They further identified that a person in a flow state will usually experience (1) a merging of action and awareness, (2) an ordered and fully investigated attention, (3) a loss of self-consciousness, (4) a sense of in control, and (5) a distorted sense of time [47]. These are the effects of flow experience.

Additionally, to achieve optimal experiences, the activities need to be “personally meaningful” to the performer. Csikszentmihalyi’s conception of this “meaningfulness” regarded three factors: (1) the purpose or goal of the activity that connects events into a network of causal relationships, (2) people’s intention that reflects their purpose in action, and (3) the order of information that reveal the relationships among events [47]. These elements of the flow theory are

symbiotic with the prerequisites of meaningful play (i.e. discernible game feedback and integrated action-outcome structure). Using these concepts of flow, meaningful play can be understood as the attributes of a game that reveal the causal relationships among gaming events (i.e. discernibility) and connects them through the player's purpose and goals within the game (i.e. integration).

Many researchers have borrowed the principles of the flow theory to understand player engagement in games [36, 44, 181]. For example, Sweetser et al. (2005) examined elements of the flow theory and their manifestation in games. From this work they proposed the influential GameFlow model [181]. Their model is comprised of a set of corresponding criteria associated with eight elements of player's flow experience (including concentration, challenge, player skill, control, clear goals, feedback, immersion, and social interaction). Those criteria can serve as heuristics in design and evaluation of games.

The literature on game studies has examined the flow theory in the context of (1) commercial games with typical players (e.g. [131]), (2) novice game genres (e.g. pervasive games [94]), (3) games played by less represented population (e.g. senior players [15, 119]), and (4) serious games, including games played in educational settings [2, 70, 90, 194] and games for health [64, 174, 184]. Many have used the GameFlow model; some also modified this model to accommodate special considerations in different types of games [16, 70, 94, 156, 194]. For instance, Sinclair et al. (2009) proposed a "dual flow" model to address the balance between "attractiveness" and "effectiveness" in motion-based games that promote physical exercises [174].

While flow theory covers many important aspects of player engagement in games, researchers have pointed out limitations of using flow theory in understanding player experiences. In particular, flow theory has been criticized as

being overly concentrated on extreme experiences in which player is highly focused and fully invested in the game [95, 128]. Further, some have suggested that player engagement also happens in the absence of flow, especially when the player's skill exceeds the challenge level of the game [117, 131, 133, 171]. As a result, researchers have investigated other constructs to further understand positive player experience, constructs including the concept of immersion (see section 1.2.2) and theories of motivation (see section 1.2.3).

### 1.2.2 Player Immersion

The word “immersion” is used widely in discussions and reviews of games (see e.g. [10, 183, 190]) to describe situations when players “lose themselves in the game world.” In this section, I focus my discussion around three major works that investigated the nature and characteristics of player immersion: (1) Brown and Cairns's model of player immersion stages [24], (2) Jennett et al.'s randomly controlled experiments to measure player immersion [95], and (3) Ermi and Märiä's categorization of player immersion [66].

Brown and Cairns (2004) conducted interview-based studies to investigate game players' perspective about the “immersive” moments when playing their favorite games. They identified that immersion as an experience develops in stages over time and this development is controlled by a set of barriers that are associated with the interaction between the player and the game [24]. According to this model, immersion starts with *Engagement* when a player begins to play a game that triggered their interest; it then develops into *Engrossment* while the player becoming more emotionally attached to the game; this experience reaches its peak in *Total Immersion*, in which the player feels a detachment from reality [24]. I summarize this immersion model in Table 1.

Table 1. Player immersion stages

<b>Stage</b>	<b>Characteristics</b>	<b>Barriers/Conditions</b>
Engagement	Player gets interested in the game and wants to keep playing	<ul style="list-style-type: none"> <li>• Player preferences</li> <li>• Game usability</li> <li>• The investment player put into the game (e.g. time, effort, attention)</li> </ul>
Engrossment	Player suspends their disbelief of the game world and emotionally involved in the game	<ul style="list-style-type: none"> <li>• Game elements that provoke player emotion</li> <li>• A distraction-free environment</li> </ul>
Total Immersion	A fleeting experience of a detachment from reality – “the game was all that mattered”	<ul style="list-style-type: none"> <li>• Empathy provoked by the game structure</li> <li>• A suitable atmosphere created by game construction (e.g. graphics, plot, sounds)</li> <li>• A high level of visual, auditory and mental attachment</li> </ul>

Jennett et al. (2008) conducted three controlled experiments in an attempt to define and measure immersion in games; they used and iterated an immersion questionnaire during the experiments. Factor analysis of their final questionnaire revealed five main characteristics of immersion: (1) cognitive involvement, (2) real world dissociation, (3) emotional involvement, (4) challenge, and (5) control [95]. However, one prominent limitation of this work is that the researchers only investigated the effects of the activity itself and overlooked the attributes of the activity performer. In particular, some of their participants reported that they were highly immersed in the supposedly non-immersive activity (clicking a box that appears randomly on screen). A qualitative analysis of participants’ comments revealed that some participants considered the box-clicking activity as a game for themselves by imposing additional goals and rules; e.g. participants tried to click the box as quickly as possible or tried to predict the location of the next box [95].

This indicated that immersion is a complex phenomenon that involves characteristics of both the activity and the player; i.e. a player's personality and preferences can also alter their likeliness to experience immersion.

Emphasizing the interaction between the game and the player, Ermi and Mäyrä (2005) proposed a model of immersion based on a series of studies exploring gaming experience of children. They generated the 'SCI gameplay experience model' in which game immersion is examined in three dimensions: (1) sensory immersion, which is related to audiovisual execution of games; (2) challenge-based immersion, which rely on a satisfying balance between challenge and player skill; and (3) imaginative immersion, which is associated with an attachment to the stories and the world the game creates [66]. They argued that this immersion model is situated in the interaction between the game and the player and is shaped by the gaming context. They further pointed out that while sensory and imaginative immersion can be found in other types of media such as virtual reality environments and movies, challenge-based immersion is the only dimension that is associated only with games; in well-designed games, these three dimensions of immersion have multiple points of overlap [66].

In summation, game immersion is understood as a phenomenon that covers a wider variety of player engagement beyond flow. Researchers have identified that while flow depicts extreme (and usually fleeting [24, 66]) situations of player experience, immersive experiences are scaled [24] and can include many categories [66]. In addition, immersion was cited to be a precondition of flow [128]. For example, reviewing studies on the enjoyment of games, Mekler et al. (2014) proposed a player experience model in which player immersion (denotes the intensity of experience) and enjoyment (denotes the "valence" of experience) served as two dimensions that interact and regulate the quality of the overall player experience; flow experience occurs when immersion and enjoyment are

both at a high level [128]. As a result, many researchers have supported the notion that flow and immersion are two important elements of player engagement in games [59, 128, 131].

### 1.2.3 Player Motivation

Motivation is defined as “the forces acting on or within an organism to initiate and direct behavior” [144]. In the context of gaming, motivation is a driving force that initiates gameplay and keeps players engaged in the game. I briefly review three frameworks investigating the mechanics underlying game motivation: (1) self-determination theory, (2) uses and gratifications theory, and (3) Malone’s theory of motivation focused on games for learning.

Self-determination theory (SDT) is an empirically derived theory of human motivation that differentiates intrinsic and extrinsic motivation; the former denotes “the doing of an activity for its inherent satisfactions,” while the latter refers to “the performance of an activity in order to attain some separable outcome” [159, 160]. SDT specified that intrinsic motivation is based on the satisfaction of three basic psychological needs: (1) *autonomy*, which concerns “a sense of volition and willingness” and can be enhanced by a sense of choice; (2) *competence*, which describes a balance between challenge and the belief of being able to overcome the challenge; and (3) *relatedness*, which describes the need to be connected with others [50]. It further divided extrinsic motivation into four types according to their level of internalization and integration into one’s need and value system: (1) external regulation, which regulates behaviors that are performed to satisfy an external demand or need; (2) introjected regulation, which involves behaviors performed to avoid guilt or to attain a feeling of worth in certain circumstances (i.e. contingent self-esteem); (3) identified regulation, which represents regulations that are accepted and owned as personally important;

and (4) integrated regulation, in which external regulation is fully assimilated to the self [159]. SDT has framed many research studies that have focused on player motivation in games [52, 54, 136, 143, 147–149, 161, 188], including serious games [52, 138, 143] and gamification [54, 136]. In the context of games for health, for example, Peng et al. (2012) conducted randomly controlled experiments and found that player autonomy and competence in an exergame independently affected enjoyment and motivation [143]. Related, in a survey-based study Osorio et al. (2012) identified that autonomy and relatedness were the two highest needs satisfied through exergame play [138].

Uses and gratifications theory (UGT) is grounded on a basic assumption that people select and use media to fulfill various kinds of psychological needs and receive the corresponding gratifications [141]. Many researchers have used UGT in games studies to frame their investigation of reasons why people play games [22, 42, 93, 106, 118, 170]. These studies usually adopted a common methodology to reflect the specification of UGT: studies framed by UGT usually start with an exploratory work (e.g. semi-structural interview with gamers) aimed to identify common motives of gameplay; this is often followed by a survey-based study that examined the identified gaming motives. Sherry et al. (2006) adopted this methodology to explain the general game use and explored the social and psychological needs satisfied in gameplay. Through an exploratory focus group study, they identified six dominant motives of video game use, including *arousal* (i.e. play games to “stimulate emotions as a result of fast action and high quality graphics”), *challenge*, *competition*, *diversion* (i.e. play games to relax, escape from stress, or avoid responsibilities), *fantasy* (i.e. play games to do things that they normally can not do in real life), and *social interaction* [170]. They then generated a survey instrument to reflect these uses and gratifications traits and administered the survey to more than 1000 participants. They found that the top



three motives of gameplay were challenge, competition, and diversion; they further identified that players' uses and gratifications traits were strong predictors of time spent playing video games [170].

Thomas Malone was one of the first researchers that investigated motivational issues in the then nascent field of educational gaming in the 1980s [120–122]. Through a series of studies in which he isolated and manipulated game features in existing games for kids, Malone proposed a theoretical framework which summarized three elements that led to intrinsic motivation in games: (1) *challenge* that relies on “a goal whose attainment is uncertain;” (2) *fantasy* that is ideally related to the players' use of skill, and (3) *curiosity* that is created through optimizing the level of information complexity [120]. Malone argued that these elements encompassed a set of heuristics that can support instructional computer game design [121]. While focused on educational games, Malone's model of player motivation can provide valuable insights to help understand and induce positive player experiences in rehabilitation games.

### **1.3 Theories About Game Design Practice**

Understanding how game designers think and work in practice provide guidance to help investigate how to support design of BI therapy games. In this section, I discuss theories about: (1) interaction design practitioners in general; (2) game designers in particular; and (3) integration of Human-Computer Interaction (HCI) methods and techniques into game design (i.e. Game User Research).

#### **1.3.1 Interaction Designers**

Based on studies with practitioners from various areas (e.g. architects and psychotherapists), Schön [168] proposed common characteristics of expert practitioners: (1) expert practitioners consider each practice situation as a unique

and undetermined case; and (2) they frequently reframe this situation through “reflection-in-action” (i.e., reflective conversations during practice that is aimed at assessing and adjusting actions in an unfolding situation). Echoing this view, Cross [137] argued that design expertise requires the abilities to solve ill-defined problems and adopt solution-focused strategies. He called for exploring “deep, underlying patterns of how designers think and act.”

The HCI community has explored the HCI and user experience (UX) practitioners’ perceptions and practices since the field is inaugurated (e.g. [79, 158]). In a seminal paper, Gould and Lewis [79] outlined three principles that defined a “user-centered” approach: (a) early focus on the user, (b) empirical measurement, and (c) iterative design. Aiming to explore how professional practitioners considered these principles, they asked the attendees of one of the earliest HCI-related talks in the 1980s to describe the major steps they regard as good practice in their work. Only a small fraction of their participants mentioned the three principles [79], indicating a large discrepancy between research and the values and practices of the industry during the early years of the HCI field.

As the interaction design profession matures, more recent related research has focused on stressing the role of designers and acknowledging their experience and skills [77, 153, 176, 178, 179, 195]. A rationale for this approach is that knowledge about designers’ values and practices will help bridge the HCI research-practice gap and support design education. For example, Goodman et al. discussed the gap between HCI research and interaction design practice; they proposed a shift in which “HCI researchers turn their attention to producing theories of interaction design practice that resonate with practitioners themselves” [77]. Stolterman et al. also proposed the concept of *Designerly Tools* aimed at exploring “methods, tools, techniques, and approaches that support design activity in a way that is appreciated by practicing designers” [178]. In an exploratory

study, the authors found that designers framed tools as having two different purposes: supporting design thinking and supporting creation of an artifact. In addition, designers considered physical or digital tools and conceptual tools (theories and approaches) in the same manner [178].

### 1.3.2 Game Designers

How game designers think and work has also been a topic of recent research [20, 80, 124]. For example, Hagen [80] interviewed six game designers from major game development studios in Sweden to understand how they considered and captured player experience in their work. He found that while all participants considered player experience as an important focus in design, most adopted an “autobiographical design” approach when capturing player experience; i.e., the designers they interviewed relied on their personal and professional experiences when approaching design and rarely leveraged user research methods to understand their target players and assess their games [80]. Related, Manker and Arvola [124] interviewed 27 game designers to understand how they perceived and practiced prototyping to support their design. They found that prototyping helped designers set and clarify the design goals and communicate design ideas to stakeholders.

There are very few studies focused on designers of serious games; many have focused on games for learning (e.g. [91, 162]). For example, Isbister et al. [91] interviewed 17 game designers within and beyond the games for learning field to explore how they considered the challenges and best practices in educational game design. Their participants claimed that serious games must be fun first and the serious contents need to be deeply integrated in the game mechanics and goals. Interviewees also expressed concerns about sparse resources (e.g. budget and time) that reduced the designers’ abilities to polish their games to

a higher level. Delving into the issue of how designers integrate serious contents into gameplay, Ryan and Charsky [162] interviewed 11 serious game practitioners. They identified several factors that influenced the success of this integration; factors included sufficient evaluation, adequate recourses, and client collaboration and understanding. Related to games for health, Mueller and Isbister [92, 130] collected game design experts' feedback about design guidelines they had created for movement-based games; the authors asked their participants to evaluate their guidelines' appropriateness, accuracy, and the communicative value.

### 1.3.3 Games User Research

The study of games and inquiries in the field of HCI had a lot of mutual influence in the past few decades [61, 96, 142]. Researchers and practitioners have investigated how HCI methods can inform game design; many focused on player-centered approaches [97, 140, 177]. While video games can be understood as a kind of computer software, they are very different from what HCI has traditionally focused on (i.e. productivity software) [12, 140]. For example, games usually require an appropriate level of challenge, while challenge in productivity software is undesired. In addition, in contrast to the determinate interaction schemes of productivity software, gameplay heavily relies on players' voluntary exploration of the game system that leads to *emerged* player experience. As a result, establishing the connection between design and user experience is more challenging in games than in productivity software. To address these unique considerations, game researchers have investigated evaluation methods that are more tailored for games and inaugurated the field of games user research (GUR).

Many research methods in GUR incorporated concepts and techniques in HCI; some differentiated game usability (which tackles the learnability of a game

and focuses on player behavior) and the evaluation of players experience in games (e.g. through playtesting) [48, 140]. The most widely used GUR methods include: (1) heuristic evaluations that do not involve participants [53, 67, 166, 181]; (2) subjective measures that gather data directly associated with participants' attitudes and opinions about a game (e.g. interview-based methods [57, 84, 145, 163], survey [18, 48, 66, 187], and diary studies [89, 107, 129, 157]); and (3) objective measures that rely on data gathering methods independent of participant bias (e.g. observation-based methods [11, 89], gameplay metrics [60, 82], and physiological metrics [123, 132]). See Figure 2 (adopted from Mandryk (2008) [123]) for a summary of these methods.

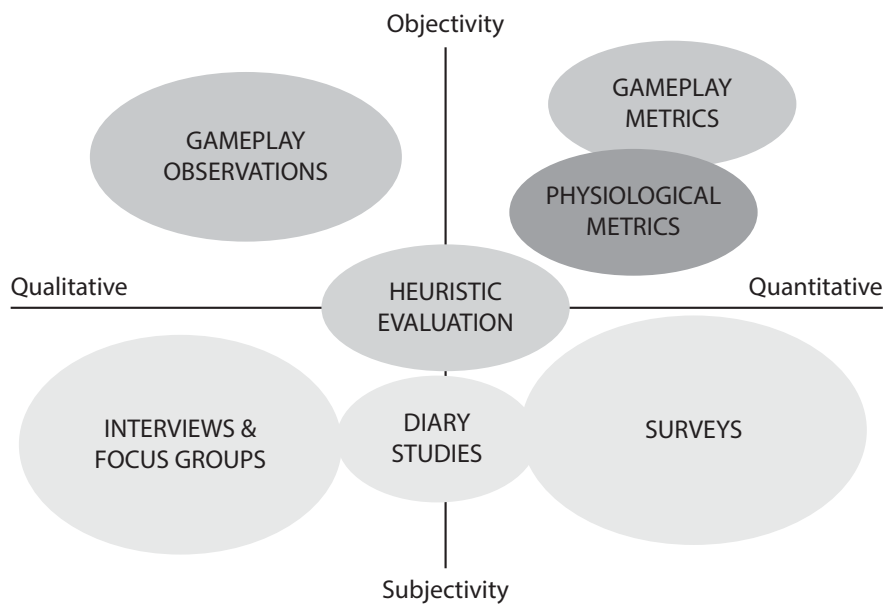


Figure 2. Summary of major games user research methods, adopted from Mandryk (2008)

## 1.4 Summary

Recall, the goal of this investigation is to support design of games for brain injury rehabilitation through game design patterns and game design tools.

The theories reviewed in this chapter provided a framework that constructs a fundamental structure of a Designer-Game-Player triad (see Figure 3). Because the goal of this project is to support game design, I positioned the game designers at the top. Particularly, game designers work in a certain design context (e.g. collaborate with other stakeholders and work under constraints such as time and budget) and leverage their reflective thinking skills to use various methods to understand their players and design games. Through game design, their goal is to provide meaningful play in order to elicit positive player experiences that facilitate flow, immersion, and motivation of their target players. Player experience is thus at the core of gameplay and is a major focus of contemporary game design. As such, the design and evaluation of games for BI rehabilitation also need to pay attention to factors contributing to player experiences in order to take full advantage of this new media.

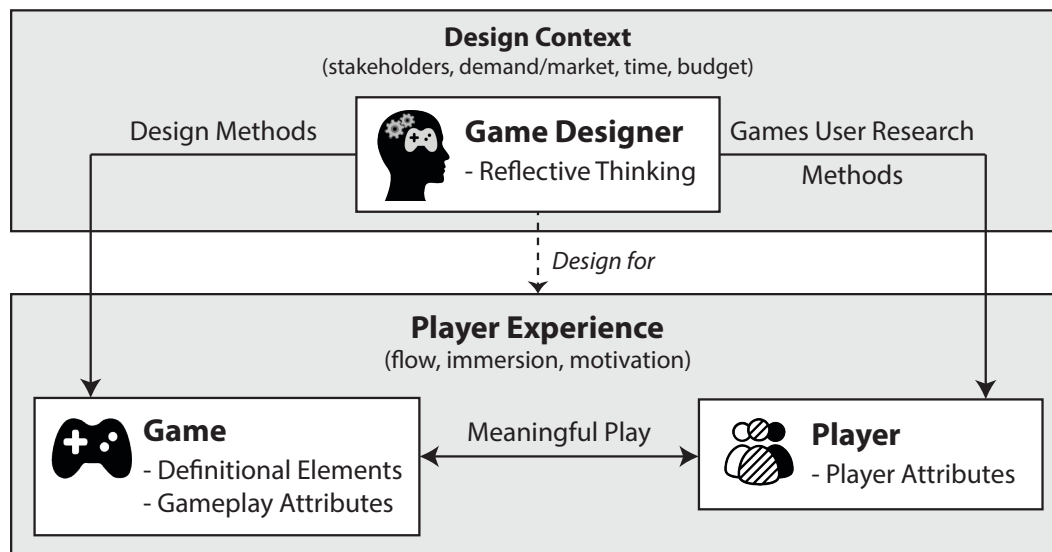


Figure 3. Designer-Game-Player triad in game design

Notably, many theories and constructs reviewed in this chapter were not specifically focusing on games for health or games for BI therapy; in other words,

I also discussed theories that were used to understand games designed for the general public and other kinds of serious games (e.g. educational games). A rationale for this was that many aspects of game studies are universally applicable to different kinds of games; the framework gained from the study of games in general can provide valuable insights to help understand games and game design in the relatively younger field of games for health and games for BI therapy. The studies and models reviewed here thus provide important insights into the design and analysis of rehabilitation games. They will frame the creation and evaluation of the BI therapy game design patterns and the corresponding game design tool in this work.

## **CHAPTER 2. BACKGROUND AND RELATED LITERATURE**

This investigation is closely related to the literature about (1) brain injuries, (2) using and creating games for BI rehabilitation, (3) game design patterns, and (4) game design tools. I review each category of the background and related research in this chapter.

### **2.1 Brain Injuries**

Brain injuries (BI) is a major public health issue affecting many societies worldwide [146]; approximately 6.4 million children and adults in the United States live with a lifelong disability as a result of a BI [154]. BIs that are acquired after birth (sometimes called acquired brain injury, or ABI [1, 51]) can have a wide range of causes, including external traumatic events such as car accidents and firearms (i.e. traumatic brain injury, or TBI [173]), loss of oxygen to the brain (i.e. hypoxic brain injury), and cerebral vascular accidents (i.e. stroke) [1, 51]. People who have sustained a BI exhibit a wide range of physical and cognitive impairments. Physical impairments can affect both gross and fine motor coordination [173], including gait and balance impairments and full or partial paralysis that is commonly associated with stroke [9, 75]. Cognitive impairments post BIs can impact attention, concentration, direction following, problem solving, memory and learning, and speech and language [40, 75]. Due to the wide-ranging causes and effects associated with BIs, rehabilitation treatments also vary widely and need to be customized by therapists; many involve repetitive



activities to reinforce efficacy. As a result, it can be challenging to motivate patients to engage in the activities needed for BI rehabilitation [17, 73, 74].

## **2.2 Games for Brain Injury Therapy**

In order to encourage patients to engage in the rehabilitation activities, many therapists include video games in their therapy sessions. Therapists have used varied combinations of (1) commercial off-the-shelf (COTS) games designed for the general public and (2) games that are specifically designed for BI therapy; choices of game use are influenced by budget and availability [7]. I discuss research in both areas in the following sections.

### **2.2.1 Commercial Games for Brain Injury Therapy**

Work that has examined commercial off-the-shelf (COTS) games presumed that these games were designed to be engaging and, if proved effective in addressing BI rehabilitation goals, they would serve as a promising candidate to achieve a balance between player engagement and rehabilitation efficacy. Researchers have investigated COTS games for BI rehabilitation on several gaming platforms, including Nintendo Wii [55, 126], Sony Play Station [69, 192], Microsoft Xbox [139], and web-based games [43, 196]. For example, Deutsch et al. (2009) conducted a between subject study comparing a Wii-based rehabilitation program with a "standard" mobility program for two participants post-stroke. They found that while the Wii-based program generated more initial enthusiasm and health improvement, greater gain was not sustained in follow-up studies [56]. More recently, Paavola et al. (2013) conducted a case study using Kinect Adventures on Xbox 360 for ten sessions over a month with a 29-year-old patient sustained a BI. Over the intervention, the participant showed improvements in movement performance and physical clinical outcomes that

included balance and gait [139]. Zickefoose et al. (2013) investigated the efficacy of Lumosity (a web-based brain training program, also available on tablets [81]) for cognitive improvement in four participants who had a TBI. They found that while participants made significant improvements through the intervention, there was limited evidence showing that cognitive skills gained were generalizable to tasks outside of the game [196]. While not focusing directly on game design, the lessons learned in the use of COTS games can greatly inform games created specifically for BI rehabilitation.

While having obvious advantages such as low cost and scalability, COTS games have several limitations for use in BI rehabilitation. For example, COTS games are usually not feasible for patients who are low functioning [155] and some games provide negative feedback that could be inappropriate for people who have had a BI [113]. As a result, therapists use COTS games only with a small portion of their patients; i.e., those who demonstrate higher physical and cognitive abilities [152]. In addition, research has supported the need to include adjustable features in rehabilitation games in order to accommodate the wide-ranging causes, effects and recovery arcs associated with BIs [3, 63]; current COTS games do not include such adjustable features that meet the diverse needs of people rehabilitating from a BI.

### 2.2.2 Creating Games for Brain Injury Therapy

To mitigate the limitation of COTS games, researchers and practitioners have created games that are designed specifically for BI rehabilitation. Much of the early work in this area has focused on games run on specialized platforms (including virtual reality systems [23, 45], motion capturing devices [169]; robotic systems [41, 68]; and touch tabletops [8]) that usually bear a high cost and thus suffer from limited scalability to general therapeutic practices. Along with the

development of motion capture technologies and the availability of motion-based game consoles (e.g. Nintendo Wii and Xbox Kinect) and portable devices (e.g. iPad), research in this area has recently shifted towards methods that create customized games leveraging commercially available hardware; many focused on games with adjustable parameters (e.g. [3]). Examples leveraging commercial hardware to create custom games include methods using low-cost webcams [29–31], Kinect sensors [72, 112], and Wii remotes [3]. For example, Burke et al. (2009) developed a series of webcam-based motion-games for stroke rehabilitation. An informal evaluation indicated that these games had the potential to support in-home therapy [31]. Researchers have also generated design guidelines for BI therapy games that are aimed at balancing therapeutic efficacy and engaging gameplay. For example, Flores et al. (2008) generated a list of design criteria for stroke rehabilitation games that also focused on entertaining elderly people [68].

### 2.2.3 Summary: Games for Brain Injury Therapy

In summation, there has been a great deal of interest in the use and creation of games for BI rehabilitation. While suffering an obvious limitation of small samples, most of the previous work in this area focused on investigating the effects of games on the patient's health improvement and general wellbeing. However, cases cited in literature have identified that currently available games for BI rehabilitation have many limitations to achieve a satisfactory balance between player experience and therapeutic efficacy. First, COTS games are often too difficult and have too steep a challenge ramp for many who have had a BI [113, 155]; second, games designed specially for rehabilitation have often overly focused on therapeutic effects at the cost of player experience [28, 185]. Consequently, designing effective, appropriate, and engaging games for BI therapy is a challenging and important area for exploration. Particularly, close

communication and mutual understanding among therapists and game designers is especially important for creating a successful rehabilitation game [28, 68]. This is an oft-overlooked area in the literature. My work in this dissertation research addresses this gap by providing game design patterns and game design tool to support game design for BI therapy and facilitate collaboration among designers and subject matter experts in serious game design process.

### **2.3 Game Design Patterns**

Based on the work of Christopher Alexander, design patterns are a collection of design concepts that have successfully solved recurring problems in corresponding contexts [5]. Design patterns in Alexander's theory: (1) are capable of supporting communication of design knowledge and fostering creativity; (2) each contain context, a description of the problem, and a solution that capture the invariant design knowledge; (3) should be interconnected and organized hierarchically; and (4) need to be iterated during design practice to realize their value [4, 5]. The concept of design patterns has been adopted in many fields, including software engineering [33, 71] and interaction design [21, 49].

Applying design patterns to support design and communication about gameplay has been discussed in the general game development community since the early 2000s [182]. Björk and Holopainen (2004) completed the most comprehensive work in this field. They conducted a series of informal but broad analysis of existing games and game design considerations through the lens of their Game Component Framework; this framework divides game components into four categories: (1) holistic components that describes play as a unique activity, (2) boundary components that limit the possible actions of players, (3) temporal components that specify the flow of games, and (4) structural components that define the physical and logical elements for player-game

interaction. Based on this analysis, Björk and Holopainen generated a set of over 200 game design patterns organized in 11 broad categories. Each of their patterns included (1) a name, (2) a core definition, (3) a description of how it is used in current games, (4) a specification of designers' choices applying the pattern, (5) the resulting gameplay of the pattern, and (6) its connections to other patterns [19]. As such, their patterns constituted a comprehensive common language of game design that could arguably be used to analyze and design games. Notably, instead of using the problem-solution structure that Alexander proposed to describe the patterns, Björk and Holopainen focused on summarizing the recurring elements and characteristics of game design (i.e. the solutions).

Many recent researchers and practitioners, however, have recognized that the problem-solution structure of game design patterns is necessary to support game designers in practice; as such, many have readopted this structure in creating new patterns [58, 88, 114, 125, 182]. Additionally, Björk and Holopainen's pattern language has been criticized for not being able to capture some of the important game design factors, such as contextual issues [99] and the expected player experience [114] and behavior [87]. Further, their patterns were not able to cover design considerations of certain game components (e.g. level design [87]) and game types (e.g. serious games [125]). To address these limitations, recent research has examined game design patterns in the context of shooter games [76, 86, 87], role-playing games (RPG) [175], online social games [115], and mobile casual games [99]. Researchers have also explored how player experiences such as flow [114] and player motivation [83, 115, 116] can be addressed using game design patterns.

Further, researchers have explored patterns in serious game design; many focused on educational games [58, 62, 88, 102, 103, 105, 125]. I identified two common themes in the literature of this area. First, researchers have used game

design patterns to address a common goal/challenge in serious game design: to balance player experience in games and the subject matter that games address [58, 78, 88, 102, 103, 125]. For example, Huynh-Kim-Bang et al. (2010) investigated how game design patterns can help combine fun and learning elements in educational games and developed two sets of design patterns focusing respectively on fun and learning aspects of games [88]. The second theme is that game design patterns were unanimously advocated as a communication tool that supports the collaboration of stakeholders in a game development team. For example, Marne et al. (2012) investigated educational game design patterns as a collaboration space to facilitate communication and mutual understanding among teachers and game designers of educational games. They identified 42 problem-oriented design patterns that can serve as a common language for stakeholders in educational game projects [125].

Only a few studies investigated design patterns for rehabilitation games [32, 78]. Goude et al. (2007) mapped game design patterns established by Björk and Holopainen with a taxonomy of common stroke rehabilitation tasks and developed a stroke rehabilitation system that includes 20 therapeutic mini-games [78]. While closely related to this investigation, Goude et al.'s work has several limitations: (1) the patterns they used were not specifically addressing therapy-centered game design issues; (2) the mapping they created was based on subjective speculations; and (3) they did not provide evaluation on the patterns and games they created. In the literature review, I was unable to find work specifically addressing BI therapy game design patterns; this research thus bridges a gap by creating a common vocabulary that will help designers focus on the needs of BI rehabilitation and support collaboration among designers and therapists during game design process. In addition, the creation of this common vocabulary was driven by data we (Dr. Cynthia Putnam and myself) gathered

about game use in BI therapy sessions and iterated through evaluations with game designers and therapists who work with people who have had a BI.

## **2.4 Game Design Tools**

It is a long-standing problem that game designers lack conceptual and computer-aided design tools to support their ideation, communication, and documentation of game design ideas [38, 134]. Game design patterns can be seen as one type of conceptual tools aimed to address this issue. Schell's *game design lenses* are another construct focused on capturing higher-level design considerations. Schell (2008) have proposed 100 lenses, each of which included a set of questions aimed at prompting game designers to focus on a certain design consideration [167].

Researchers have also created software tools to support game designers. For example, Karakaya et al. [100] developed a game ideation tool called 'Sketch-It-Up!' that allows game designers and other stakeholders to explore and communicate design ideas. More closely related to this investigation, in his master's thesis Kuittinen [109] embedded Björk and Holopainen's game design patterns in a software tool for Computer-Aided Game Design (CAGE). In doing so, he intended to support designers to select appropriate patterns by providing a visual representation of the inter-relationships among the patterns. While preliminary, Kuittinen's work demonstrated an early effort in incorporating game design patterns in game design tools.

More recently, researchers have explored requirements for game design tools. For example, Nelson and Mateas [135] conducted job shadowing and interviews with three teams of independent game designers to understand their needs for a game design tool. Reviewing current and proposed game design

approaches, Almeida and Silva [6] also identified a list of 14 general requirements for game design tools. Their requirements specified that a game design tool must: (1) define a formal structure for a collection of design concepts (e.g. game design patterns); (2) provide a software system to support the use and extension of this collection; and (3) consider both the designer's perspective and the player's perspective [6].

In the literature review, I did not find work that focused on tools specifically aimed at therapy-centered game design. Building on previous studies, this dissertation seeks to explore meaningful ways to incorporate BI therapy game design patterns in a game design tool.

## **2.5 Summary**

In this chapter, I reviewed the literature that is closely related to this investigation; namely, the use and creation of games for BI therapy and game design patterns and design tools. In summation, many therapists who work with patients who have had a BI have included games to ameliorate boredom associated with repetitive rehabilitation. However, designing effective, appropriate, and engaging games for BI therapy is challenging. Particularly, an oft-overlooked area in the literature is research to investigate how to support successful collaboration among game designers and subject matter experts (therapists in this case). Design tools that incorporate game design patterns are a promising approach to address this issue. However, there has been little work directly focused on patterns and tools for therapy-centered game design.

This research thus addresses the limitation in literature by focusing on exploring techniques to support game design for BI therapy and facilitate collaboration among designers and subject matter experts in serious game design



process. Through this investigation, I also demonstrate a novel research methodology for domains in which balancing the role of designers and other stakeholders is particularly important, such as the domain of game design for BI therapy.

## **CHAPTER 3. PRELIMINARY WORK: UNDERSTANDING GAME USE IN BRAIN INJURY THERAPY**

This research is directly built upon a parallel project led by Dr. Cynthia Putnam in which we explored means to support therapists using games in BI rehabilitation. To lay the foundation, we worked with therapists at Schwab Rehabilitation Hospital in Chicago and the Marianjoy Rehabilitation Hospital in Wheaton, Illinois to explore the use of COTS video games in BI therapies; we aimed to provide decision and information-sharing tools to help therapists choose games for their patients who have had a BI. In this chapter, I discuss our previous work that was directly linked to this dissertation, including (1) interviews with therapists to understand their COTS game use, (2) observations of game therapy sessions, and (3) creation of a game therapy case base.

### **3.1 Interviews with Therapists About Game Use**

We began our collaboration with both rehabilitation hospitals by interviewing therapists to understand how they currently use COTS games in BI therapy. We interviewed 21 therapists that included five occupational therapists (OTs), nine physical therapists (PTs), three recreational therapists (OTs), and four speech-language pathologists (SLPs). Interviews were conducted in June and September of 2012 at the Schwab Rehabilitation Hospital and in September 2013 at Marianjoy Rehabilitation Hospital; each interview took between 30 and 45 minutes. Therapists were asked to describe: (1) games they used and the approximate percentage of patients for whom they included game; (2) therapy

goals they targeted when using the games; (3) their motivations for using games; (4) patient and game factors that contributed to how games were chosen; and (5) changes desired in current games and/or features they would include if they could design games for their patients. We then transcribed and inductively coded the interviews. Major themes identified in data analysis included:

(a) *Motivations*: The most common motivation for using games in therapies was to (1) add fun and introduce something novel, followed by (2) a desire to distract patients and (3) introduce more challenge for high functional patients. Therapists who were involved with group gaming sessions also used games to encourage social interaction.

(b) *Patient factors that affected game use*: The top factors mentioned were cognitive and physical abilities. Patients' age and previous gaming experience were also considered important inter-related factors; therapists were much more likely to use games with younger patients who had past gaming experience.

(c) *Game factors that affected game use*: Therapists discussed choosing a specific game because it facilitated an activity that the patient had enjoyed prior to injury, e.g., bowling and golf. In addition, therapists also chose games to fulfill a particular therapy goal such as weight shifting and balancing.

(d) *Desired changes*: The most common desired changes were associated with issues related to the game controls; e.g. therapists expressed that the Wii controllers often posed fine motor requirements that exceeded the patients' abilities. Therapists also desired the ability to adjust several game parameters, including timing, challenge level, and the amount of stimulation (i.e., noise and visual distractions). Several therapists also mentioned that they wanted games that simulate real-life activities. (For more details, see our paper that focused on the interviews [152].)

### 3.2 Observations of Game Therapy Sessions

After the initial interviews with the therapists, we assembled two AV carts at each site that held three commercial game consoles (Wii, Xbox Kinect, and Sony Move) and multiple games requested by the therapists. We then conducted on-site observations of therapists using games during inpatient therapy sessions. The observations were aimed at further understanding game use in BI therapy in context.

During our on-site days, we asked the participating therapists to inform us whenever they had a therapy session in which they would use games. Observations required therapists to complete a ‘documentation of capacity’ in which they assessed that the patient had the capacity to understand our consent forms. We were able to observe 24 therapy sessions at Schwab and Marianjoy in 2012-2013. While we were physically present, we avoided contact with the therapists and patients during the session. Major findings in the observations included:

*Timing in play sessions:* In our observations, only about 30% of the session time was used for gameplay. Transferring the patient before and after the session as well as taking breaks during the session took about 45% of the time. Further, game setup, loading, and the display of game results also took a considerable amount of time (about 25% of session time).

*Support provided:* We identified several kinds of patient support that therapists needed to provide to streamline the gameplay. Common physical supports included (1) protection from falling and (2) additional physical scaffolding such as hand-over-hand assist with remotes and bearing some of the patient’s weight. Therapists also provided various types of cognitive support before, during, and after gameplay, including: (1) teaching or reminding of game

rules; (2) providing strategic/tactic instructions, suggestions, and/or feedback; (3) teaching patients the “correct” movements to play the game; and (4) guiding the patient going through the game setup or dealing with non-play UI issues during gameplay.

*Reinforcing therapeutic values:* We identified three ways therapists promoted therapy activities to assured that patients got the therapy out of gameplay: (1) emphasizing certain postures or movements related to therapy goals, (2) posing additional requirements on movement, and (3) adding equipment (e.g. foam board) to introduce additional challenge associated with a certain goal.

*Enjoyment:* Major factors associated with the enjoyment in gameplay included: (1) a right amount of challenge, (2) a sense of being in control (e.g. being able to understand game rules and being able to perform the basic mechanics), and (3) a sense of progress (e.g. increased score from the last play and improved skill in the game).

For more details of the observations, see [37]. The findings from the therapist interviews and observations of game therapy sessions have provided important context for this dissertation. In addition, analyzing the observation data has directly contributed to the creation of a subset of game design patterns (experience-centered patterns) in this research (see 5.1.2).

### **3.3 Constructing a Game Therapy Case Base**

From the interviews and observations, the concept of a game therapy ‘case’ evolved. To further understand the details about game use in BI therapy sessions, we constructed a game therapy case base about therapists’ accounts of including games in BI therapy. An analysis of this case base has directly resulted in the creation of a subset of game design patterns (efficacy-centered patterns) in

this research (see 5.1.1). In the next section, I discuss the structure of a game therapy case and our previous work constructing the case base.

### 3.3.1 Structure of a Game Therapy Case

A game therapy case in our study describes a particular situation in which a game is used with a patient to address certain therapy goals. Each case contains information about: (1) patient attributes (e.g. player abilities and preferences); (2) therapy session goals; (3) game/console affordances, mechanics, and requirements; and (4) subjective measures of session outcome (e.g. effectiveness on therapy goals). See Figure 4 for a summary of the attributes of a case.

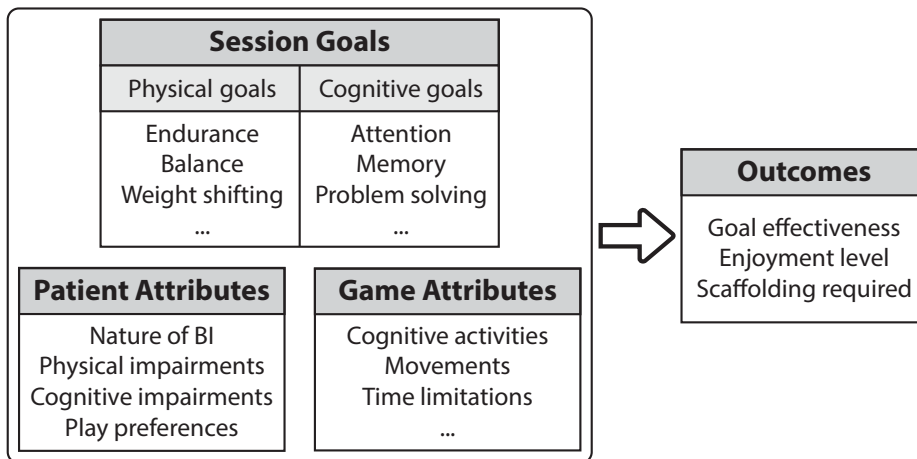


Figure 4. Summary attributes of a case

### 3.3.2 Case Collection

To construct the game therapy case base, we first conducted paper-based diary studies with therapists at Schwab and Marianjoy to collect initial game therapy cases. We then expanded the case collection methods by including digital diary forms in user feedback questionnaires during user studies of a game recommendation tool that we developed to help therapists choose appropriate COTS games for their patients.

### *3.3.2.1 Paper-Based Diary Studies*

To collect the initial game therapy cases, we conducted paper-based diary studies with therapists from Schwab and Marianjoy. In the diary studies, therapists were given a notebook containing a two-page paper diary form and were asked to record details about play sessions over two-week study periods. We piloted and iterated the diary forms in October 2012 at Schwab; see Figure 5 and Figure 6 for the final version of the diary form.

On the diary forms, therapists were asked to input information about (1) session details, such as time/date and the number of patients involved; (2) non-identifiable patient details, such as age, gender, nature of the BI, assistive devices used, play personality based on Stuart Brown's work (see section 1.1.2), and details about patient's physical and cognitive abilities; (3) the games they chose to use; (4) the therapy goals for playing each game and corresponding subjective measures of effectiveness (-2 to +2) of the game at meeting each goal; (5) subjective measures of cognitive and physical help needed to play the game; and (6) subjective evaluation of patient enjoyment and engagement.

We conducted seven periods of two-week diary studies (three at Schwab and four at Marianjoy) from December 2012 to June 2014. In total, 16 therapists participated in the paper-based diary studies, including nine physical therapists (PTs), three occupational therapists (OTs), two speech-language pathologists (SLPs), and two recreational therapists (RTs). Therapists recorded data for 89 individual patients, ages ranging from 19-95 ( $M = 53.5$ ); patients included 49 males and 40 females. Through the seven diary periods, we collected 244 seed cases about game use in inpatient BI therapy. These cases constituted the initial game therapy case base.

Date: \_\_\_\_\_ Time: \_\_\_\_\_ Group size: **1 2 3 4 5+**

Is this the first session with this patient? Yes  No

Were other therapists involved in the session? Yes  No

Was Legsys data collected? Yes  No

If multiple therapists involved, describe therapists roles:

---

**Patient Info**

Patient Initials: \_\_\_\_\_

Age: \_\_\_\_\_

Gender: \_\_\_\_\_

Admission FIM score: \_\_\_\_\_

Impairment group code: \_\_\_\_\_

Gender:Berg Balance: \_\_\_\_\_

Dynamic Gait: \_\_\_\_\_

Fugl-Meyer: \_\_\_\_\_

Mayo-Portland Adaptability Inventory-4: \_\_\_\_\_

Notes: Describe patient's injury and your primary goals for this session:

---

**Cognition**

Command following

Problem solving

Low Level High Level

**Movement (upper body)**

None Full range

Right Arm

Left Arm

**Finger flexation**

Right Hand

Left Hand

**Fine motor coordination**

Right Hand

Left Hand

Low level High level

---

**Standing (lower body)**

Uses Wheelchair

Uses Walker

Uses Cane

Standing endurance

0 10 20 more Minutes

---

**Games played**

Console: (Wii, Kinect, Move) \_\_\_\_\_ Game/mini-game: \_\_\_\_\_

1. \_\_\_\_\_

2. \_\_\_\_\_

3. \_\_\_\_\_

4. \_\_\_\_\_

---

**Questions for patients**

**1. Do you play video games on your own?**  
(Describe)

**2. Play personality**  
Lay out the eight play personality cards in the notebook pocket and ask the patient to identify which describes them best, then second best, and least:

**Best?**  **Second best?**  **Least?**

Figure 5. Final version of the paper-based diary form (page 1)



**Check Goals** that apply. Then rate each game's effectiveness at meeting that goal

	Not effective	Effective	Very effective	Not effective	Effective	Very effective	Not effective	Effective	Very effective	Not effective	Effective	Very effective								
<b>Social &amp; Cognitive goals</b>	Game 1:			Game 2:			Game 3:			Game 4:										
Attention <input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
Command following <input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
Comprehension <input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
Concentration <input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
Communication <input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
Insight into deficits <input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
Problem solving <input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
Safety <input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
Sequencing <input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
Socialization <input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
Task Initiation <input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
Visual perceptual skills <input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
Verbal reasoning <input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
Turn taking <input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
<input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
<input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
<b>Physical goals</b>																				
Bilateral hand use <input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
Dynamic balance <input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
Endurance <input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
Fine motor <input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
Hand-eye coordination <input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
Standing <input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
Static Balance <input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
<input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
<input type="checkbox"/>	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2	-2	-1	E	+1	+2
<b>Enjoyment</b>	☹️ 😐 😊 😄 😁			☹️ 😐 😊 😄 😁			☹️ 😐 😊 😄 😁			☹️ 😐 😊 😄 😁										
<b>Cognitive help needed</b>	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
<b>Physical help needed</b>	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4
<b>Boredom v. Frustration</b>	B ← 2 1 0 1 2 → F					B ← 2 1 0 1 2 → F					B ← 2 1 0 1 2 → F					B ← 2 1 0 1 2 → F				
<b>What type of fun?</b> Check all that apply	<input type="checkbox"/> H <input type="checkbox"/> E <input type="checkbox"/> S <input type="checkbox"/> P			<input type="checkbox"/> H <input type="checkbox"/> E <input type="checkbox"/> S <input type="checkbox"/> P			<input type="checkbox"/> H <input type="checkbox"/> E <input type="checkbox"/> S <input type="checkbox"/> P			<input type="checkbox"/> H <input type="checkbox"/> E <input type="checkbox"/> S <input type="checkbox"/> P										
	H = Hard fun: achieving a goal, competing w/ oneself						E = Easy fun: curiosity, surprise, wonder													
	S = Serious fun: excitement, esteem from learning						P = People fun: social, cooperation, competition													
<b>Session NOTES:</b> What deterred from enjoyment? Anything else you would like to add? (use the back if needed)																				

Figure 6. Final version of the paper-based diary form (page 2)

### 3.3.2.2 Digital Diary Forms

With the initial cases gathered in paper-based diary studies, we created a ‘Choose a Game’ tool prototype to help therapists use games with their patients. Using this tool, the therapists were able to input patient attributes and session goals and then get a list of games recommended for the input situation based on the cases we collected (see [150, 151] for details about the ‘Choose a Game’ tool).

We conducted user studies of the prototype system with 29 therapists in three testing periods between August 18, 2014 and June 30, 2015. During the beta test periods, therapists were asked to make at least three inquiries per four weeks. The therapists’ inquiries during the evaluation studies were automatically logged to the system; each inquiry included information about session goals and patient attributes that represented the first page of the diary form. After each therapist inquiry, we sent a questionnaire asking about the therapy session and their experience using the tool. As part of the questionnaire, therapists were asked to complete questions about the session and game use that paralleled the second page of the diary (i.e. rated the effectiveness of the games at meeting the specified session goals, the level of cognitive and physical help needed, patient enjoyment and the challenge level). As a result, the inquiry and the corresponding questionnaire served as a digital diary form that resulted in new cases added to the case base.

The 29 participating therapists made 299 queries in which games were used in a therapy session. (Note that a single query could result in multiple cases if multiple games were used.) The new cases collected from the inquiry and survey returns ( $n = 472$ ) were combined with the paper-based diary cases ( $n = 244$ ) to create a total of 716 cases for the current case base that covers 413 unique therapy sessions and contains data about 157 games/mini-games from 51 games on five different platforms.

### **3.4 Summary**

In our previous studies, we aimed to understand game use in BI therapy from the therapists' perspective. As mentioned earlier, there are many limitations in the existing games used for BI rehabilitation. There is a great need for research investigating game design to fully support and promote game use in BI therapy; an essential direction is to combine professional knowledge of therapists and game designers to support the creation of therapy-centered games. In this dissertation, I focus on techniques to support game design for BI therapy and facilitate collaboration among game designers and subject matter experts. Our previous work discussed in this chapter has provided important context for this investigation and has directly resulted in the creation of the BI therapy game design patterns.

## **CHAPTER 4. PHASE ONE: UNDERSTANDING DESIGNERS OF GAMES FOR HEALTH**

Games for BI therapy constitute a thriving area of serious games for health (i.e., a type of serious games that targets health related goals). Game designers who focus on games for health (including BI therapy games) often face unique and significant challenges in their work. In their day-to-day practice, they collaborate with various stakeholders, research the subject matter, interact with target players, and strive to make their end products accessible and engaging while delivering the intended health objectives. However, there is little research examining how these designers perceive and overcome these challenges. Understanding the values and practices of this group of game designers is thus a needed first step to explore methods and tools that can better support BI therapy game design.

In this chapter, I describe an interview study aimed to accumulate insights from professional game designers who focus on games for health. In particular, I was interested in understanding: (1) how the designers judge and perceive success of games-for-health projects; (2) how they think about and act on the challenges in their work; (3) how they acquired domain knowledge and assessed their games; and (4) what “tools” they used to support their work. For the last point, I adopted Stolterman et al.’s concept of *Designerly Tools* that include concepts, theories, and artifacts that supported design activity [178]. Through this study, I aimed to explore the context and requirements for the BI therapy game design patterns and

design tools. This phase of the study was published in the ACM conference on game and play (CHI Play '16) [38].

## **4.1 Methods**

This study was based on interviews with 11 professional game designers who were working in the field of games for health. In the following sections, I discuss the recruitment process and participants, the interview protocol, and the data analysis procedure.

### **4.1.1 Participants**

I began the recruitment process by identifying authors or presenters from the Games for Health Journal (22 issues from February 2012 to August 2015) and the Games for Health Conference (2013 and 2014) who were associated with a professional game design studio. I then followed each studio's website and collected names and contact information (if available) of the game designers in the studio. Among the 48 game designers I identified, I was able to obtain an email address contact for 30 designers. I sent recruitment emails to those 30 designers; 11 responded and completed the interview.

Among the 11 participants I interviewed, nine were from the United States (from five states including Illinois, Wisconsin, Pennsylvania, Texas, and California), one was from the Netherlands, and one was from the UK; interviewees included seven males and four females. All participants had a job title that included "designer" or "creative director" and considered game design as their main responsibility. Their professional experience as game designers varied between 3 and 23 years. All participants had actively worked on games-for-health projects during the past three years; many were designing a game for health at the time of the interview. All but one participant had also worked on game projects

beyond games for health, including commercial entertainment games and games for learning. Table 2 summarizes professional experiences of the interview participants.

Table 2. Summary of interview participants' professional experiences

<b>ID</b>	<b>Job title</b>	<b>Years as game designer</b>	<b># of games for health designed</b>	<b>% of games for health in all projects</b>
P1	Creative Director	8	7	66%
P2	Head of Game Design	23	3	10%
P3	Senior Game Designer	10	3	20%
P4	Creative Director	15	3	20%
P5	Lead Designer	20	25	80%
P6	Lead Designer	5	2	50%
P7	VP of Design	13	10	50%
P8	Art Director	8	4	25%
P9	Game Designer	9	10	50%
P10	Lead Designer	8	2	30%
P11	Game Designer	3	10	100%

(All data were collected at the time of the interview.)

While most participants focused on digital games ( $N = 8$ ), two had exclusively worked on tabletop games and the remaining one focused on active games that are played in a real-world space. The health goals participants had considered included promoting a healthy behavior ( $N = 5$ ), addressing a mental health issue (e.g. anxiety) ( $N = 4$ ), increasing awareness or empathy of a health condition (e.g. depression) ( $N = 2$ ), supporting conversations around health related issues (e.g. sex and sexuality among teens) ( $N = 2$ ), and promoting physical exercise ( $N = 2$ ).

#### 4.1.2 Interviews

I conducted the interviews between October and December 2015. All but one interview was conducted via phone calls or VoIP; the remaining one was conducted in-person. During the interviews, I asked participants about many aspects as to how they think and act in practice, including: (1) processes they followed to design games for health; (2) their most and least successful games-for-health projects and their accounts related to success and failure; (3) methods they used to acquire domain knowledge and to explore the needs of their target players; (4) methods they used to evaluate their games; (5) the biggest challenges they considered in games-for-health design; and (6) the tools they used for designing games for health. See Appendix C for the material I used in this study. Each interview took between 30 and 45 minutes; interviews were audio-recorded and later fully transcribed.

#### 4.1.3 Data Analysis

I adopted a grounded theory approach [35] and followed four steps in analyzing the transcribed interviews.

1. I first conducted structural coding [164] of the interviews to identify the major topics and the corresponding text segments. The topics identified in this step included (1) general approach, (2) success, (3) challenge, (4) domain research and game evaluation, and (5) tools used.
2. Myself and another researcher independently analyzed the interviews and inductively coded for salient themes in each structural topic identified in step 1. After independent analysis, we discussed our codes and reached an agreement on the themes we identified. I then wrote a codebook to describe how to identify those themes; in the codebook, each theme was associated with one or more structural topics (see Appendix G).

3. I then invited a third researcher who was not involved in the interviews and the codebook creation process (i.e. a blind coder) to use the codebook and deductively code the interviews. I then calculated inter-rater reliability using Cohen's kappa through binary agreement with the blind coder (i.e. if a theme was identified at least once within a structural topic in the interview, I coded it "Yes").

## 4.2 Findings

Among all the themes included in the codebook, the average inter-rater reliability based on Cohen's kappa was 0.68 ( $SD = 0.27$ ); a kappa statistic between 0.60 and 0.80 is considered a "substantial" agreement [111]. In the following sections, I only report on themes in which inter-rater reliability was considered substantial or better (Cohen's kappa is 0.60 or greater) *and* at least three interviewees mentioned the theme. Those themes were categorized into the four overarching topics based on the structural coding: (1) success, (2) challenges in design, (3) domain research and game evaluation methods, and (4) tools used in design.

### 4.2.1 Success

I asked participants to describe their most and least successful games-for-health projects and reflect on why they felt the games were successful or unsuccessful. When discussing this topic, participants mentioned two top-level themes: (1) specifics about *criteria* they considered when determining the success of a game for health and (2) specifics about *factors* that contributed to the successfulness or unsuccessfulness of a game for health. When coding these themes, I consolidated the designers' opinions and reflections on both successful



and unsuccessful projects; i.e. similar criteria or factors were discussed in both successful and unsuccessful projects.

#### *4.2.1.1 Success Criteria*

When discussing how they judged the success of a game for health project, participants mentioned standards and criteria that fell into one of the three categories: (a) the game's effectiveness at addressing the targeted health goals, (b) a balance between engagement and efficacy, and (c) adoption and/or publicity of the game.

(a) Eight participants considered meeting the game's serious objectives (i.e. the health goals) as a criterion of success. For example, P5 explicitly mentioned that he would generally regard efficacy and effectiveness as the top success measure:

*“The measure of success is whether your hypothesis turns out to be true. You know, I could measure success based on unit sales. But you are very limited on that. I would really measure it on efficacy and on effectiveness.”*

When considering a game designed to support children with an attention deficit hyperactivity disorder (ADHD), P9 discussed its success around clinical tests and meeting the serious goals:

*“That is a rare thing – that is it was really tested clinically and validated. ... I think in that case. It was really successful. And I think it really provided the users with all the goals they needed to have with the game.”*

(b) Five participants explicitly discussed player experience and considered achieving a balance between player engagement and goal efficacy as a success

criterion. For example, when talking about the same game supporting children with ADHD, P9 also stressed the importance of balancing efficacy with engaging gameplay; he mentioned that this consideration is more associated with his own perspective as a game designer:

*“If I look at that project, I think it was one of my biggest successes in terms of how to make a real game that also has these serious elements in it. ... That’s always a delicate balance between how serious something gets and how fun it is to play. ... So from my point of view as a designer, it was a really successful game.”*

P2, a veteran commercial game designer who recently entered the area of games for health, discussed the differences between success of a commercial game and a game for health; he emphasized the importance of embedding engagement into the game to support the serious contents:

*“We can't typically design a game like you would in entertainment. You would have to look at the learning and health goals, talk with subject matter experts, and come up with very unique ways in order to add that fun factor or engagement in the game. That really is embedded in how those goals come across.”*

(c) Seven participants mentioned that they considered a wide adoption and/or a considerable publicity as a measure of success. For example, P4 considered a game aimed at helping youths understand medical knowledge as successful because it had “*won some awards.*” P8 also mentioned a wide adoption when talking about the success of a unique game that leveraged biofeedback mechanisms for young people to understand and manage anxiety; in addition to the standard mouse and keyboard control, the game reacts to changes in players’

physiological state such as pulse and sweat monitored using biofeedback hardware:

*“This game has been used in a variety of environments and it’s our most requested game. So in that respect, that made it a uniquely successful product for us.”*

While P9 considered the game for children with ADHD as successful in terms of effectiveness and a balance between player engagement and goal efficacy, he lamented about the low adoption of the game:

*“But unfortunately, it wasn’t really a success with the rollout. I think not a lot of people actually played the game. ... That’s a bit sad.”*

#### *4.2.1.2 Success Factors*

Participants discussed various factors that contributed to the success of their games. I categorized the factors into four groups: (a) direct interaction with target players, (b) stakeholder communication and cooperation, (c) successful game design elements and design choices, and (d) iteration.

(a) Seven participants considered direct interaction with target players as an important factor to achieve success. Many mentioned that including target players in a participatory design process or during playtest sessions had helped them understand the characteristics and needs of their players and/or had provided insightful information for designing the games. For example, when talking about a game to promote healthy behavior for patients who have had a heart failure, P7 mentioned that insights gained from interviews with target players had motivated him to adopt a minimalist game design style that had contributed to the success of the game:

*“What we found in our interviews with patients at the beginning of our design process was that even the basic literacy level of many of the patients is super low. ... And people’s scientific literacy and medical literacy was even lower. So we really, really simplified it.”*

(b) Six participants considered the quality of the partnership with other stakeholders (e.g. the client or subject matter experts) and the support they acquired from the stakeholders as a factor contributing to the games’ success. For example, P7 mentioned a good partnership with other team members had allowed the designer to embrace his minimalist game design style:

*“Luckily we had a team that trusted us and I had a lot of support from the folks we were working with. So we were able to say, ‘we are really going to focus on these complete really basic ideas.’”*

Some participants also valued the domain and user information provided by the subject matter experts (i.e. medical and healthcare experts) that helped achieve success of the game. For example, P9 emphasized the support he acquired from the client and the subject matter experts:

*“We had a team of researchers at our disposal that was really involved in the whole process. ... They knew everything about the subject and we could iterate with them on how we should implement that in the game.”*

Poor partnership with stakeholders would also negatively affect the game’s success. When talking about an unsuccessful game, P9 considered a scenario in which an assertive client can impede a designer’s effort to achieve a balance between player engagement and goal efficacy:

*“Especially if the client is really pushing its vision on the game through, then you have a game that the client think is great but the users are not that interested about it – players are just not engaged and they don’t like to play the game. Then basically it fails to meet the goals that you set for the project.”*

(c) Seven participants mentioned general game design elements (e.g. narratives, challenge, etc.) or specific design choices when discussing factors contributed to the success of a game. For example, P3 designed an iPad game aimed at supporting youths at risk of sexually transmitted diseases; she mentioned that focusing on narratives and delivering an authentic experience helped to make the game successful:

*“We focused on narrative and making important decisions and seeing the outcome of the decisions. ... We also focused on trying to capture the narrative quality of stories that these players would see in their everyday life, trying to make it feel authentic so that they would be interested – kind of like they were interested in what's happening to themselves and their peers.”*

P8 also emphasized game narratives in a game for anxiety management; he strived for combining novel technology and narratives to create a unique player experience:

*“There is the novel aspect of it: We merged clinical techniques and eastern techniques [of anxiety management] into our own mythic world. So it has a very unique narrative. Also, it’s a game that works with the biofeedback device, which a lot of people are not doing.”*

(d) Three participants explicitly mentioned that design iteration is key to creating successful games. For example, P2 provided an insightful summary of his design philosophy, in which he valued the combination of subject matter expert support, direct interaction with target players, and iteration:

*“I got up with that whole idea of, you know, more time with subject matter experts and more time with focus-testing and iterating on design, the better the game would be. I think that's the key in any game for impact.”*

#### 4.2.2 Challenges in Design

I identified six themes in participants’ consideration of the major challenges in games-for-health design: (a) combining engagement and the serious game goals, (b) consolidating interests of subject matter experts and game designers, (c) evaluating efficacy, (d) working with limited resources, (e) achieving lasting impact and interest, and (f) overcoming stereotypes associated with gaming.

(a) Six participants felt a major challenge in games-for-health design is to achieve a balance between player engagement and the game’s effectiveness at addressing the health goals. On one hand, participants regarded achieving the health goal via an engaging game as challenging. For example, P3 said:

*“The biggest challenge is that it’s always a tall order. It's not just about designing an engaging game. But you have to really be aware of the research, you have to really investigate the problem, and you have other metrics for success in addition to the game is engaging – you also have to achieve the purpose. So I think there is just a lot more requirements for this kind of game.”*

On the other hand, many participants also emphasized the difficulty of achieving player engagement in games for health and lamented on the lack of engagement in many current games. For example, P2 mentioned:

*“The biggest challenge is making it still feel like a game. It's ultimately its name, you know, a ‘game for health’, versus a ‘task for health’. There are a lot of games out there that are just tasks. So the challenge is trying to embed that goal in a very playful way ... so it should come across very naturally.”*

(b) Four participants mentioned that it is often challenging to consolidate the different mindsets, interests, and motivations between the subject matter experts and the designers. For example, P2 talked about the conflicts they often meet and the compromise they often have to make when working with subject matter experts:

*“On almost every project we come to this point of compromise, where as game designers, we are trying to add very game-like motivations and trying to embed and hide the serious goals in there, and then the PIs or the subject matter experts are scientists and they are looking at it from science. So they tend to want to just see the serious goals in every interface. So what usually ended up happening is we strip out what we call the fun and engagement part of it and we end up putting in like ‘look what you are getting’ in your face – because that makes them feel better.”*

P4 discussed the same issue and felt the severity of the issue “*depends on how well the subject experts understand games.*” P5 also emphasized the difficulty to communicate with subject matter experts because of this difference on mindsets and focuses:

*“One of the barriers to serious game development is the disconnect between game developers and the serious content providers. They often do not speak the same language or understand each other’s areas. ... Especially in healthcare, many of the subject experts are not game players. ... So when talking about games they may understand the words but not be able to relate it to an experience in their own fund of knowledge.”*

(c) Three participants considered measuring the efficacy of games for health as a major challenge. Participants mentioned various reasons for the difficulty of measuring efficacy. First, it is sometimes difficult to define the proper metrics for efficacy in games for health. Second, a proper measurement requires resources such as time and committed partners that are often limited in games-for-health projects. Third, a proper evaluation on efficacy is usually done when the game is finished and it has little value to feedback to the design iterations. Mentioning all three reasons, P7 said:

*“I think the biggest challenge is measurement – to actually do a pilot and get a scientifically rigorous assessment about whether or not the intervention is successful. The problem we face is also that it takes a long time. It takes a really committed partner. And it’s really hard to iterate when you have to wait for six months or a year to get data from a study like that.”*

(d) Three participants also emphasized that games-for-health projects usually have to work around limited resources such as time and budget, which poses a considerable challenge. For example, P3 considered limited budget is one reason that constrained the quality of some games-for-health projects:



*“I think one of the biggest challenges is that we have to do more with less. The projects are usually underfunded. ... The typically funded, they are in smaller amounts as compared to traditional entertainment games. ... I think that is one of the reasons why some of these games struggle with quality.”*

(e) Three participants mentioned that it is often challenging for games for health to achieve sustainable impacts and maintain lasting player interest. P1 also associated this challenge of sustainability with limited budget:

*“I think the biggest challenge is promoting lasting change and having a sustainable experience. There is a novelty value to every game – people play it for a while ... and often you come to know that over time this novelty wears off very quickly. ... Since we don't have much money to create a huge game for health, it is a problem using one or two intervention and then people play it for an hour and you are done. So being able to milk that positive benefit of games for a longer amount of time is a huge challenge.”*

(f) Three participants considered a challenge for games for health is to handle stereotypes associated with gaming. For example, P6 designed a board game aimed at supporting communication around end of life topics; a big challenge he experienced when promoting this game was a stereotype that people think games are not serious:

*“Especially at the beginning when we were starting the design of the game and trying to get people interested in it, particularly because this is a very serious topic, people don't think games are appropriate for this kind of thing. ... A few weeks ago, there was a big event where people play the game and afterwards several*

*people came up and said, 'I really enjoyed it. We had a lot of fun. But don't call it a game.' And I think there is a disconnection about what a game is."*

#### 4.2.3 Domain Research and Game Evaluation Methods

I asked participants to describe methods they had used to understand the domain and the target players and methods they had used to evaluate their games. I organized these methods into two top-level themes: (1) before-prototype methods and (2) after-prototype methods.

##### *4.2.3.1 Before-Prototype Methods*

Before creating a game prototype, participants mentioned use of various methods to understand the subject matter topic, explore the characteristics and needs of targeted players, and refine the game's objectives. I grouped the before-prototype methods into three major types: (a) get support from subject matter experts, (b) directly interact with target players, and (c) read materials about the domain. These methods eventually supported the designers in brainstorming and prototyping.

(a) All 11 participants acquired some kind of support from subject matter experts before prototyping starts in at least one of their games-for-health projects. However, the level and the form of subject matter experts' involvement varied.

Some participants gained subject matter experts' help from informal conversations. For example, P1 mentioned that she regularly talked with a medical school professor who focused on the treatment of anxiety disorders to acquire knowledge about this subject.

In contrast, some games-for-health projects were led by or partnered with a research group focused on the subject matter. For example, P7 mentioned that he usually get subject matter experts' support from this kind of partnership:

*“We start with our client and our partner. They often have subject matter experts. So we start there to learn what they believe the context would be. They are not our players – they are not our end audience. But they do inform the criteria for success and what they believe to be the correct objectives.”*

In some cases, game development studios had hired subject matter experts to support their design. For example, P8 discussed how they hired different types of experts throughout the design process:

*“We usually have two levels of experts. We have people who are generalists. They come in early and set the table for the domain. ... We sometimes call them ‘storytellers.’ They help the whole team get familiar with and start understanding the domain. Then once we drill in, and we start knowing what we are going to focus. We bring in content experts. They really know a lot about specific things. We work with them to make sure what we are doing is accurate.”*

(b) Seven participants mentioned that they had directly interacted with target players (via e.g. interviews, focus groups, and/or informal conversations) prior to creating a prototype to understand the domain and player needs. For example, P7 stated that he usually conducted interviews with target players before creating a prototype:

*“We generally follow a player-centric design process, where we try to do interviews with our target audience up front. ... When we talk to representative players, we were really looking for ‘What’s their baseline?’ You know. ‘What are their attitude about the content? What do they know? What don’t they know? What do they want to know more about?’ We also have general questions about games: ‘Do they play games? What kind of games? How do they feel about games?’”*

(c) Four participants also mentioned that they read materials such as research papers or books to understand the domain and the target players. For example, when designing a game aimed at supporting youths at risk for sexually transmitted diseases, P3 mentioned that after interacting with subject matter experts they further explored the domain through research materials:

*“[After subject experts focus groups,] we then drew from the body of research around behavior change that is long-standing. So we were looking at that research.”*

#### *4.2.3.2 After-Prototype Methods*

Participants adopted several methods to help evaluate and iterate the prototypes they created. These methods fell into one of the two major categories: (a) playtests that are conducted by the designers themselves and (b) formal research studies that are usually conducted with the support of subject matter experts and focused on game efficacy.

(a) All 11 participants have conducted playtests with target players to help explore the effectiveness, the gameplay, and/or other aspects such as narratives and artwork of their prototypes. The methods participants used in playtests included observations of player behavior ( $N = 6$ ), interviews or focus groups with

the players ( $N = 5$ ), surveys during or after playtest sessions ( $N = 4$ ), and remote tests leveraging telemetry data or player diaries ( $N = 3$ ). P9 mentioned all four playtest methods by saying:

*“So when you can actually observe it, it gives you the most insight. But we can’t always be there. So sometimes we just provide them with the game and they can test it at home. Then they can fill in, for example, surveys online and provide us with feedback. We recently tested a game and let players play it at home. We then had a telephone survey – we call them and ask them how they were doing and how it was the gameplay. So that’s a media between seeing it and just letting them fill in the questionnaire.”*

Participants also expressed concerns with three factors about how to conduct playtest:

1. *Early and often.* Eight of the participants mentioned that they tended to conduct playtests early and often in the development cycle. For example, P7 mentioned: *“As soon as we had something built, usually our first prototype, we do playtesting with representative players and collect data from it. These then inform our iterative development process. We playtest as much as we can in the course of the development.”*
2. *Obscuring the purposeful goal.* Four participants mentioned that they intentionally obscured the purposeful goals of the game from the players during playtests to see if the goal emerges from play. For example, when talking about playtesting a game that aimed at promoting awareness and empathy about people who are living with depression, P1 mentioned: *“In the beginning we didn’t tell them because I wanted to see whether the experience came across without their knowing what it was about – did we*

*really capture, with the mechanisms and the game structure alone, that feeling of helplessness of loss and frustration – because that was the point.”*

3. *Group/social testing.* Four participants mentioned that they included multiple participants in the same playtest session to encourage feedback. For example, when talking about playtesting a game aimed at helping children understand medical knowledge, P4 said, *“Often we will have kids paired up and you want to get them talk to each other. ... And also, it can be helpful for keeping them honest.”*

(b) Three participants mentioned that they collaborated with subject matter experts to conduct formal research studies to evaluate the game’s effectiveness at addressing the serious goals. For example, P6 mentioned that a research team they were collaborating with was actively evaluating the game for end-of-life communication:

*“The research team is actually the one that’s doing much more in-depth studies of how people play the game. They actually do audio and video recording of every game. And then they have a methodology called the Multiple Goals Framework to assess communication qualities.”*

#### 4.2.4 Tools Used in Design

I asked participants to discuss tools they had used that supported their design of games for health; I explicitly asked them to consider “physical, digital, and conceptual tools.” Participants considered several types of tools that included (a) theoretical frameworks, (b) design philosophy or design process, and (c) early prototyping methods. Very few participants mentioned physical and digital tools.

(a) Seven of the participants mentioned that they have used theoretical frameworks that are either published or internal to the participant's organization to support their design; those frameworks included (1) theories about the domain or the subject matter ( $N = 3$ ), (2) works about game design in general (such as Jesse Schell's game design lenses [167],  $N = 3$ ), and (3) frameworks about serious game design ( $N = 2$ ). For example, P7 mentioned that he had used both published and internal frameworks to support his work:

*"We leverage Bloom's taxonomy to think about the learning and behavior change objectives. ... We also developed internally in our studio a model of elements of game for behavior change. And that model certainly informs how we approach the design of a game."*

(b) Four participants considered a certain design philosophy or a certain aspect of their design process as a "tool." For example, P7 considered a design process of determining the game's objectives up front as a tool:

*"I would say that a tool is really our design process, particularly in the very beginning. ... I mentioned the idea of determining learning objectives and behavior objectives up front. ... That really helps us drive the focus early in the project."*

Several participants also mentioned using other existing games as a tool to support inspiration or communication. For example, P2 said:

*"When working with the PIs and the researchers, one of the tools is playing other games. ... Because a lot of times the people we were working with aren't gamers. So I think games themselves become tools that helped the communication and design."*

(c) Three participants considered early prototyping methods (e.g. using pencil and paper or board game pieces) as tools to support design. For example, P8 considered paper prototyping as a tool to design a digital game:

*“A tool is really paper prototyping. Sometimes we even first do it as a board game or a card game.”*

### **4.3 Discussion**

In this interview study, I explored how game designers who focused on games for health perceived and approached designing games. In the following sections I discuss the major implications of this study.

#### **4.3.1 Games-for-Health Designers Are Very User-Centric**

In the interviews, I found that most games-for-health designers valued and practiced Gould and Lewis’s three principles of user-centered design, i.e. early focus on the user, empirical measurement, and iterative design [79]. Further, most participants mentioned interviews or focus groups with target players as one of their first steps approaching a game for health project; many also regarded direct user involvement as an important factor that contributed to the success of their games. These findings suggested that games-for-health designers tend to put a lot of emphasis on early user involvement and user research.

Notably, this finding is inconsistent with Hagen’s discoveries about the practice of some commercial entertainment game designers; while limited on sample size, Hagen [80] found that his entertainment-focused game designer participants tended not to leverage early user research in their work. This discrepancy between the health and entertainment game designers indicates that the nature of the game projects may have influenced their approaches. Target



players of games for health often have special health-related attributes that are not familiar to the designers. In addition, many of the user attributes essential to game design (e.g. target users' play preferences) are also unique to the user group (e.g. an elderly population). As a result, it is crucial for the games-for-health designers to pay special attention to their target players and conduct user research themselves to understand the player attributes.

My interview participants also mentioned that they have adapted common Games User Research (GUR) methods to fit in the unique context of games-for-health design. For example, many participants said that they often obscured the health goals in playtesting sessions to see if those goals were embedded in play. Interviewees also discussed how playtesting methods were limited in establishing the efficacy of the game at meeting health goals; as a result, many participants had resorted to more formal research studies.

#### 4.3.2 Problem-Focused vs. Solution-Focused

Nigel Cross [137] argued that, unlike problem-focused professionals (e.g. scientists), designers usually adopt a solution-focused strategy when approaching a design problem. According to Cross, designers are often faced with ill-defined and ill-structured problems; as a result, they prefer to approach a problem by synthesizing lessons learned from “planning, inventing, making and doing” to create a satisfactory solution. While I found that games-for-health designers are also generally solution-focused, many participants in the interviews approached game design by exploring both the problem and the solution spaces somewhat equally.

On one hand, all interviewees were committed to iterative prototyping and playtesting when approaching game design. Participants also relied on this iterative process to refine their understanding of the domain and the target users

(i.e. the problem space). On the other hand, I also found that many participants put a lot of emphasis on before-prototype methods; i.e. they devoted considerable effort to explore the subject matter and the needs of the target players even before creating the first prototype. Additionally, some participants put more emphasis on before-prototype methods than others; i.e. there was a spectrum of problem-focused tendency among the interview participants. In particular, some mentioned that they strived to clearly define the serious objectives and the efficacy measures of a proposed game before approaching design.

This tendency of approaching design from the problem and the solution spaces somewhat equally is very important to serious game designers; Vasalou et al. [186] also emphasized pre-prototyping efforts when developing an educational game. This tendency among games-for-health designers may have two originating sources. First, games-for-health designers are facing complex problems that are often unfamiliar to them. As such, they often have to acquire a great amount of domain knowledge in order to approach the initial design; this is also associated with their early user focus tendency. Second, games-for-health designers often work closely with subject matter experts and other stakeholders who are more accustomed to problem-focused approaches. For example, some of the game projects discussed in the interviews were initiated or funded through a research project led by medical professionals. As a result, designers often need to adjust their approaches to maintain effective collaboration and communication with these stakeholders.

#### 4.3.3 Games-for-Health Design Is a Challenging Area

Entertainment and serious game designers all face significant challenges when considering the design of engaging experiences; however the latter group also have to steer player experience to deliver a purposeful goal. Some of my

findings about challenges facing games-for-health designers were in agreement with the literature focused on other groups of serious game designers. For example, my findings supported that embedding serious content into an engaging gameplay experience is a crucial but difficult aspect [26, 27, 162]; in addition, maintaining successful stakeholder collaboration is also important but challenging in serious game projects [28, 104].

I have also identified several challenges that are particularly important for games-for-health designers. For example, when compared to educational games, which are usually focused on delivering specific knowledge or skill, games for health often focus on more subtle (e.g. behavior change) or long-term (e.g. rehabilitation) effects. As such, my interviewees considered establishing efficacy of the games as a significant challenge. In addition, games-for-health players are diverse; in some areas (e.g. games for elderly adults), the target users are not typically familiar with the game media. So dealing with stereotypes (and sometimes stigmas) associated with gaming was perceived as a challenging aspect by some of my interviewees.

When addressing those challenges, interviewees tended to be more problem-oriented and very user-centric in their practice. However, their user-centered efforts did not always help with some of the prominent challenges such as communicating with subject matter experts and achieving lasting player experiences. These findings indicated that more research is needed to help support games-for-health designers overcome the challenges interviewees discussed.

#### 4.3.4 Success of Games for Health Is a Complex Issue

While delivering an engaging player experience is usually the success criteria of most entertainment games, my interviewees discussed the success of their games-for-health projects in more complex ways. When I asked the

participants to describe their successful and unsuccessful games, they usually started by qualifying the definition of success and continued in discussing multiple aspects of the project, indicating that they did not consider success as a one-dimensional phenomenon. This multi-dimensional and sometimes context-based view of success is likely to be associated with the challenges designers meet in their work. For example, designers need to balance the needs of various stakeholders including subject matter experts, clients, players, and/or caregivers when approaching their design vision.

In research that has explored factors contributing to the success of serious games, many have proposed game design elements, such as appropriate challenge and meaningful feedback, as success factors (e.g. [14, 110, 193]). In this study, however, participants valued process and methodological issues (e.g. interaction with target players, stakeholder communication) over specific game design elements when considering factors leading to success. While I acknowledge game design elements are important components, designers' emphasis on design methodologies and approaches indicated that more research is needed in this area.

#### 4.3.5 Tools Are Mostly Theoretical and Conceptual

When discussing tools used to support design, my participants took account of major consideration on theoretical frameworks and conceptual approaches. This consideration of theoretical and conceptual tools supports Stolterman et al.'s concept of *Designerly Tools* [178]; i.e. designers value artifacts, methods, and theories similarly as tools. It also resonates with the recent efforts in related literature that explored game designers' accounts of theoretical and conceptual tools [80, 92, 124]. For example, in agreement with Manker and Arvola [124], my participants also considered early prototyping methods as tools to support generating and communicating design ideas. I argue that the designers'

emphasis on theoretical and conceptual tools provides insights for both researchers and educators concerned with games for health; i.e. the need to emphasize investigation and teaching about these tools.

Further, very few of the participants mentioned the use of physical or digital tools to support their design. Some participants also expressed dissatisfaction about the lack of design tools. Specifically, my interviewees voiced a need for information tools to help them understand the subject matter and collaborate with other stakeholders. As such, investigating information tools for serious game designers is a valuable future area to explore.

#### **4.4 Conclusions**

Through this interview study, I found that designers focused on games for health tended to be very user-centric and emphasized early involvement of target players. The designers' user-centered efforts, however, did not always help with many challenges they met in their work. For example, many designers of games for health found it difficult to consolidate the different mindsets and motivations with the subject matter experts (e.g. therapists in BI therapy games). Specifically, the subject matter experts tended to be narrowly focused on the purposeful goals of the game, while the game designers often lacked knowledge about the context in which the game would be played. Further, my interviewees voiced a need for conceptual and information tools to support ideation and communication of game design ideas. These insights motivated and guided the creation of BI therapy game design patterns and the GaPBIT game design tool in this dissertation research.

## CHAPTER 5. PHASE TWO: IDENTIFYING BRAIN INJURY THERAPY GAME DESIGN PATTERNS

Game design patterns were identified as effective in facilitating communication among game designers and subject matter experts in the game design process [78, 102, 125]. BI therapy game design patterns could thus potentially help game designers overcome some of the tough challenges discussed in Chapter 4. I investigated the BI therapy game design patterns in a data-driven approach that involved analysis of the observation data and the game therapy case base that Dr. Putnam and I had created (see Chapter 3). I divided the game design patterns into two groups: (1) *efficacy-centered* patterns that focus on enforcing the effectiveness of games at addressing BI therapy goals and (2) *experience-centered* patterns that focus on fostering in-game experience of patients who have had a BI. In this chapter, I discuss the data-driven method I used to create the game design patterns and provide an overview of patterns generated through this method; I also describe a user study that explored designers' early feedback on the patterns. For a full list and description of all the BI therapy game design patterns, see Appendices A and B. Discussion about efficacy-centered patterns has been published as [39].

### 5.1 Methods for Discovering Game Design Patterns

I generated both *efficacy-centered* and *experience-centered* patterns by distilling common game design elements from the most “suitable” commercial games used in BI therapy; the “suitableness” was defined differently when

considering the two groups. Particularly, the efficacy-centered patterns were generated from the most therapeutically effective games identified using the case base (see section 3.3) that synthesized therapists' account of game efficacy in BI therapy. The experience-centered patterns, on the other hand, were generated from inductive coding of the game therapy observation sessions (see section 3.2) in which the patients were most engaged in the games. I discuss the details of those methods in this section.

#### 5.1.1 Discovering Efficacy-Centered Game Design Patterns

Recall, the case base is comprised of 716 "game-therapy cases" that contains information about: (1) patient abilities; (2) therapy session goals; (3) game/console selection; and (4) therapists' subjective measures of the game's effectiveness on therapy goals. I followed five steps to generate the efficacy-centered game design patterns based on these cases.

Step 1: I calculated pairwise Pearson correlation coefficients among the effectiveness of physical and cognitive goals to explore associations among the therapy goals. This analysis of association among goals allowed identification of patterns that address multiple goals and supported analysis of the potential interactions among patterns in later steps.

Step 2: For each goal, I gathered cases addressing the goal and created a list of games that were most frequently used in those cases (i.e. I grouped the games according to the therapy goals they address and identified the most frequently used games for each goal). I included games that were used in more than ten cases addressing the goal. If there were less than five games in the list, I also included games used in more than eight cases.

Step 3: For each list of games (i.e. most frequently used games for each goal), I conducted a Kruskal-Wallis test to evaluate differences among the game's average effectiveness score for the particular goal; recall the scores were subjective ratings assessed by therapists. When there was a significant difference, I conducted pairwise Mann-Whitney U tests (with Bonferroni p-value adjustments) to identify the most effective and ineffective games for the goal. I identified a game as effective at addressing a goal if its average effectiveness score on the goal was higher than four (on a scale of 1-5). I labeled a game as ineffective at addressing a goal if the average effectiveness score was statistically significantly different from the score for at least one effective game. These games and their relationships to the goals formed the basis of the pattern generation.

Step 4: I extracted the common game design elements in the most effective games (generated from Step 3) for each therapy goal and generated the initial list of patterns. I then refined the pattern list and writing. In particular, I focused on extracting game design elements that contributed to their effectiveness at addressing the targeted goals. When appropriate, I compared the effective and ineffective games for a certain goal to identify important differences. When available, I also incorporated the therapists' comments explaining why they gave the effectiveness score to a game.

Step 5: I finally organized the patterns into four categories and analyzed the potential interactions and relationships among the patterns.

Figure 7 illustrates a condensed version of this process with an example therapy goal and design pattern.



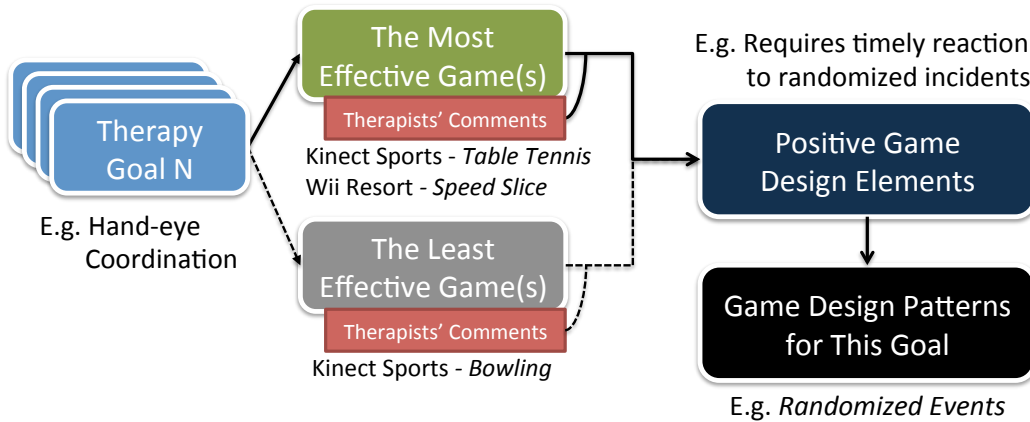


Figure 7. Method for identifying efficacy-centered patterns

### 5.1.2 Discovering Experience-Centered Game Design Patterns

Following an inductive process, I analyzed the observation video recordings of 24 game therapy sessions (see section 3.2) to discover the experience-centered game design patterns. The data analysis process followed five steps.

Step 1: I first conducted “structural coding” [164] to identify the major activities during the therapy session. Specifically, I coded for (1) game setup and loading, (2) playing games, (3) viewing the display of game results, (4) transferring the patient before and after the session, (5) taking breaks.

Step 2: For each time period in which the patient was playing the game, I conducted a “magnitude coding” [164] to generate a five-level rating about the degree of engagement the patient had when playing the game. This rating is based on my subjective observation about the patient’s level of engagement (see Appendix H).

Step 3: For sessions rated five (very engaged) and one (very unengaged), I coded for the game design elements that had contributed to the patient’s engagement or lack of engagement.

Step 4: I then synthesized the common game design elements and generated the initial list of patterns. For those game design elements that led to a lack of engagement, I described the pattern as the opposite of the design element and included the games having the element as “anti-example” games.

Step 5: I finally organized the patterns into four categories and analyzed the potential interactions and relationships among the patterns.

Figure 8 illustrates a condensed version of this process with an example design pattern.

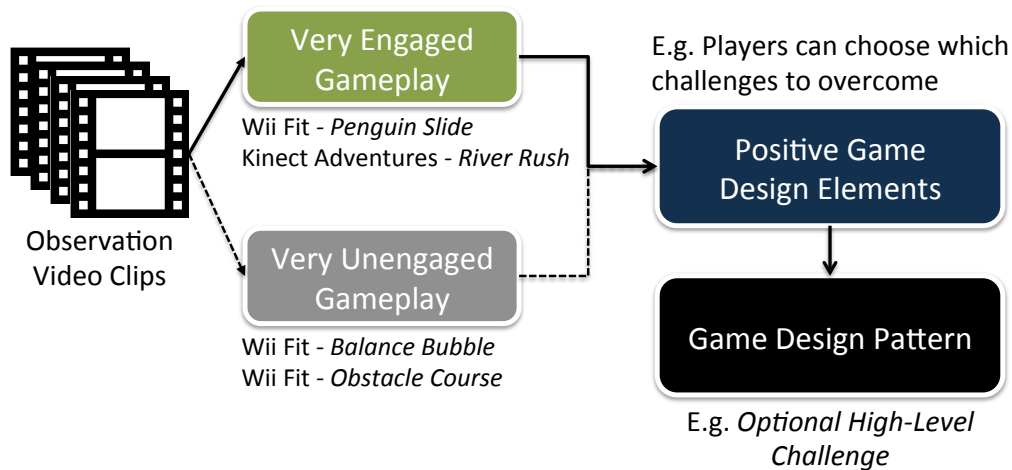


Figure 8. Method for discovering experience-centered patterns

## 5.2 Patterns Overview

Using the methods outlined in section 5.1, I generated 14 efficacy-centered patterns and 11 experience-centered patterns. See Figure 9 for a

summary of those patterns. Each pattern in this pattern library contains (1) a name, (2) a category, (3) (for efficacy-centered patterns) a set of associated therapeutic goals, (4) a problem statement describing conflicts in design, (5) a solution proposed to resolve the problem, (6) example games demonstrating how this pattern is used in current games, and (7) a list of related patterns. In this section, I provide one efficacy-centered pattern and one experience-centered pattern as examples. Appendices A and B include a full list and description of all the BI therapy game design patterns.

### **Efficacy-Centered Patterns**

#### **Game Rules Patterns**

- Fine Control
- Minimalist Task
- Optimal/Adjustable Pace
- Step by Step
- Unpredictable Events

#### **Physical Mechanics Patterns**

- Change Hands
- Integrated Standing Duration
- Moving Different Body Parts
- Self-Paced Weight Shifting
- Weight Shifting to the Extremes

#### **Perception Patterns**

- Focus and Distraction
- Three-Dimensional Space

#### **Social Patterns**

- Collocated Multiplayer
- Turn-Based Multiplayer

### **Experience-Centered Patterns**

#### **Challenge Patterns**

- Multiplayer Competition
- Optional High-Level Challenge

#### **Progress Patterns**

- Advancing
- Optimistic Performance Evaluation

#### **Learn and Master Patterns**

- Adjustable Speed
- Gentle Challenge Ramp
- Minimized Distraction
- Pick up and Play

#### **Theme Patterns**

- Age Appropriate Theme
- Enabling Theme
- Familiar Theme

Figure 9. Summary of the BI therapy game design patterns

### 5.2.1 Efficacy-Centered Pattern Example

In this section, I provide one efficacy-centered game design pattern as an example. The pattern ***Change Hands*** proposes a physical mechanic that involves movements of both sides of the body to promote the *bilateral hand use* therapy goal.

*Problem:* Patients with a brain injury may have a dominant side they prefer to use. Reestablishing the functionality of the non-dominant side can be a challenge in brain injury rehabilitation. A game that only requires movements of one side of the body may discourage the player from using their non-dominant side.

*Solution:* Involve movements of both sides of the body in the game. Include mechanics to encourage change of hands, arms, and/or legs so the players can work on their non-dominant side.

*Example Game –* Kinect Sports ‘Boxing’: Players punch in the air to attack the opponent (either another player or a computer opponent) or hold both arms in front of face to defend. In order to effectively attack and defend, player needs to use both arms. (Game control: Kinect Sensor)

The pattern document also included additional example games and specified the related patterns; see A.1.1.

### 5.2.2 Experience-Centered Pattern Example

In this section, I provide one experience-centered design pattern as an example. The pattern ***Optional High-Level Challenge*** focuses on a challenge structure that avoids intimidating low-level patients and at the same time engages patients with better abilities.

*Problem:* Because of the wide range of physical and cognitive effects of BIs, it is difficult to identify a “right” level of challenge to accommodate a range of patients who have had a BI.

*Solution:* Provide regular challenges throughout the play but occasionally give the player optional higher-level challenges. The high-level challenges should NOT be associated with the progress of the game; instead, they should provide appropriate incentives (e.g. bonuses) to encourage players to accomplish them.

*Example game – Wii Fit ‘Penguin Slide’:* Players stand on a platform (about 2 inches high) and shift their weight from side to side; this movement controls an iceberg on-screen so that a penguin character can slide to catch fish that are jumping from the water. Blue and green fish (easier to catch) provide lower points. Red fish are very difficult to catch and provide the highest points, but are optional challenges.

*Anti-example game – Wii Fit ‘Balance Bubble’:* A player avatar stands in a bubble suspended in a river. Players shift their weight on the balance platform to control the speed and direction of the bubble to follow the river’s path; the goal is to reach the finish line while avoiding the riverbank and obstacles. Some obstacles are extremely difficult to avoid for patients with a BI. However, whenever the bubble hits the bank or an obstacle, the player has to start from the very beginning of the level, which can result in frustration.

The pattern document also included additional example games and specified the related patterns; see B.1.2.

### 5.3 Early User Feedback on the Game Design Patterns

During the same timeframe as the interviews with the games-for-health designers (outlined in Chapter 4), I asked interviewees about their experience using game design patterns. I also provided examples of the BI therapy game design patterns and collected feedback from the participants.

#### 5.3.1 Methods

The 11 professional games-for-health designers from the initial interviews participated in this part of the study (see section 4.1.1 for participant details). One week before each study, I sent to the participants a document including two BI therapy game design pattern examples, *Change Hands* (an efficacy-centered pattern described in section 5.2.1) and *Optional High-Level Challenge* (an experience-centered pattern described in section 5.2.2). I first asked the participants to identify their familiarity and experience with game design patterns; I provided a brief introduction if participants were not familiar with the concept. I then asked them to provide feedback that included two things they liked and two things they did not like about each example pattern. To help explore their feedback, I asked them to consider a scenario in which they were working with an occupational therapist to promote bilateral hand use in a game. Interviews were audio-recorded and later fully transcribed. I then inductively coded the transcripts to identify major themes.

#### 5.3.2 Findings

Participants' experience with game design patterns varied. Three game designers mentioned that they have used Björk and Holopainen's game design patterns [19] in their work. Four were familiar with the concept but had never used patterns in practice. The remaining four designers were not familiar with design patterns prior to the study. Participants generally expressed interest and

satisfaction with the example patterns. The top factors associated with the positive comments included:

- The patterns express straightforward game design concepts in a concise manner. E.g., *“I think it provides a very simple compact concept to be integrated into the game mechanic.”*
- The problem-solution structure can help users understand the appropriate situations in which the patterns are intended to be used. E.g., *“It’s very good to state the problem – why would you even use this pattern – and then provide a solution exactly for that problem.”*
- The example games can help users better comprehend the core ideas of the patterns. E.g., *“It’s good to have those examples so that you can actually understand what the description is intended to convey.”*
- The patterns are interconnected via categories and related patterns to potentially form a complex network. E.g., *“The related patterns are handy because that helps you with what is already there – saying ‘maybe you need to consider these as well’.”*

Participants also voiced concerns associated with various areas of the BI therapy game design patterns. The most prominent concerns were about the example games presented in the patterns. First, participants wanted to see more example games to better understand different ways in which a pattern can be used. Second, participants desired more visuals (e.g. screenshots of example games) to better grasp how the example games realized the pattern. Third, participants desired more information about game consoles and controls, considering such information as helpful for them to discuss the example games and the patterns

with stakeholders who are not familiar with gaming. I refined all pattern documents based on the participants' feedback.

In support of the concept of using patterns in serious game design, participants indicated a desire to have similar game design patterns in their focus health area. They discussed potential benefits of game design patterns that I categorized into three main groups:

(a) Seven participants mentioned that game design patterns could help them sharpen focus during game ideation. E.g., *“The big thing that I get from those patterns is sort of a clearer idea of what is most likely to work.”*

(b) Five participants considered game design patterns to be helpful for them to explore the problem space and understand the domain. E.g., *“I think mostly what those patterns do is opening up possibilities, possibilities for what you could accomplish with games in that domain.”*

(c) Three participants mentioned that the patterns could help them collaborate with other stakeholders, including subject matter experts. E.g., *“I think those can really illustrate things so that both the game developer and the expert content providers can ultimately sit down and say ‘Yeah, this is a right kind of thing for this particular area.’”*

## **5.4 Discussion and Conclusions**

Following a data-driven approach, I generated a pattern library that includes two groups of design patterns for BI therapy games: (1) *efficacy-centered* patterns that address therapeutic effectiveness of the games and (2) *experience-centered* patterns that promote gameplay experience of patients with a BI. I also



iterated the patterns based on feedback from 11 game designers; the initial feedback was generally positive.

Adopting the concept of design patterns allowed the capture of information about the most “successful” games for BI rehabilitation in a structure that can facilitate sharing and expanding this body of design knowledge. Including the problem-solution structure in the BI therapy game design patterns could also facilitate choosing and proper use of the patterns; this is especially valuable because games-for-health designers tend to focus on both the problem and the solution spaces of their design situation (see Chapter 4). Further, design patterns helped to distill multiple variables from the large volumes of data we (Dr. Cynthia Putnam and myself) gathered about game use in real-world therapy settings; in other words, patterns facilitated sense-making of this data for designers who are interested in creating games for BI rehabilitation. This pattern library is thus capable of serving as a common language for designing BI rehabilitation games and can potentially facilitate communication and mutual understanding among game designers and therapists who focus on BI.

It is worth noting that, some of the final steps in the pattern discovery process relied on my subjective judgment in structuring and distilling the patterns from games and gameplay sessions. This is common in many design pattern generation processes [5, 19]. However, the data-driven approach I followed in this study ensured reliability in identifying the successful and unsuccessful games used in BI therapy and thus strengthened the validity of the patterns. The subjective aspects in the pattern generation process were also mitigated with user studies described in this and the following chapters.

As all kinds of design patterns, these BI therapy game design patterns should not be considered as guidelines that designers “should” follow. Instead,

designers are advised to treat these patterns as a toolkit that help them generate creative game design ideas [19]. For this reason, I strived to describe the patterns at a high level of abstraction. While covering the most prominent game design considerations that are important in creating games for BI therapy, this pattern library is obviously not a comprehensive pattern language for BI therapy game design. I plan to expand this pattern library in future work.

In the next chapters, I describe a game design tool created based on this pattern library. The structure and content of the BI therapy game design patterns have directly guided the user interface design of the tool.

## **CHAPTER 6. PHASE THREE: CREATING GAPBIT, A DESIGN TOOL FOR BI THERAPY GAMES**

GaPBIT (**G**ame **D**esign **P**atterns for **B**rain **I**njury **T**herapy) is a game design tool that leveraged the patterns to support the creation of games for BI therapy and helps to facilitate collaboration among designers and therapists during the design process. I created the initial user interface wireframes (line drawings illustrating functionality and information hierarchy) for GaPBIT based on the structure of the BI therapy game design patterns. I then evaluated and iterated several levels of interface prototypes through usability studies with six game designers. The current version of GaPBIT is a responsive web-based tool (<http://gametherapy.cstcis.cti.depaul.edu:8888>). In the following sections, I introduce the interaction design of GaPBIT and describe the user-centered design iteration process.

### **6.1 GaPBIT Interaction Design**

In the current version, the homepage of GaPBIT provides background about game design for BI therapy and indicates three main functions of the system: (1) browse game design patterns focusing on therapy goals (i.e. efficacy-centered patterns); (2) browse game design patterns focusing on player experience (i.e. experience-centered patterns); and (3) save patterns to a personalized library and retrieve the saved patterns. For each pattern browsing function, the system provides different views that organize the patterns according to their name, therapy goal (for efficacy-centered patterns), category, and interrelations.

Users can then find detailed information by clicking on the pattern. The detailed pattern information page includes the pattern's name, category, a one-to-two sentence definition, the problem and solution descriptions, and the example games. The tool also provides graphs and textual descriptions explaining how each example game realized the pattern; additionally, each game included comments from the therapists who previously used it in therapy. Users also have the option to save the current pattern to their personalized pattern library. The system supports browsing the interconnected patterns network by providing links to: (1) patterns addressing the same therapy goals (for efficacy-centered patterns); (2) patterns of the same category; and (3) related patterns. As illustrated in Figure 10, from the detailed pattern information page users are able to navigate to the connected patterns and save patterns to their personalized library.

## **6.2 Usability Study Methods**

I conducted usability studies to iterate on the GaPBIT interface prototypes between March and April 2016 with six game designers who were involved in the original interviews; participants included three males and three females. During the usability studies, participants were asked to complete four tasks using a think-aloud protocol:

1. Get a piece of background information about game design for BI therapy;
2. Choose two efficacy-centered design patterns for a scenario about BI therapy and brainstorm game design ideas using those patterns;
3. Choose two experience-centered design patterns for a scenario about BI therapy and identify relevant player characteristics using those patterns;
4. Identify related game design patterns.

**1. Detailed pattern information**

**2. View patterns of the same category**

**3. Navigate to a related pattern**

**4. Save a pattern**

Figure 10. Example user interaction paths in the detailed pattern information page

Upon completing the tasks, participants were asked to provide feedback about the browsing features and the information provided in the patterns. Finally, participants were debriefed about their experience using the prototype. See Appendix D for the material I used in this study.

### **6.3 User Feedback and Design Iteration**

All six participants were able to complete the four tasks and many expressed excitement about the tool concept. For example, a designer focused on creating card/board games that address adolescent sexual health issues said, *“I totally love it. I really mean it. ... I would definitely use this if it were from my specific content expertise. ... Because you are providing multiple pathways to shake loose deeper ideas, I think it really helps getting past the surface.”*

Participants also commented on the potential collaboration value of the tool; e.g. a designer who created iPad games addressing young adults’ health issues mentioned, *“I think there is a lot of potential here – not only for designers, but also for therapists to think about games – to have words to talk about why games might be useful for a particular brain injury. ... Once you have these terms, they are very powerful in communicating with other people.”*

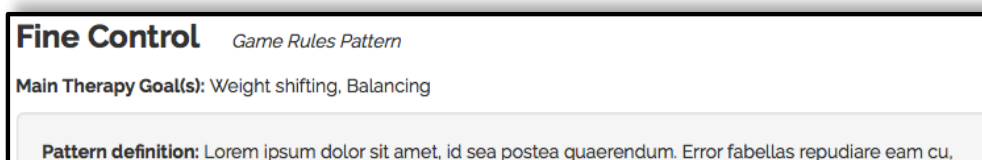
Participants also provided input that contributed to the design iteration of GaPBIT. I made several functional and visual modifications based on the designers’ feedback throughout the usability study period. I discuss the major modifications in this section.

#### **6.3.1 Enhancing Navigation Among Interconnected Patterns**

GaPBIT connects the patterns through (1) therapy goals (for efficacy-centered patterns), (2) pattern category, and (3) related patterns. All three types of links were represented in the pattern list page using the corresponding views. In

the detailed pattern information page, however, the initial design only allows users to navigate to other patterns through related patterns; the therapy goals and pattern categories are listed but not navigable. Participants of the usability study voiced dissatisfaction about this lack of navigability. Reacting to this feedback, I added links in the pattern information page that allow navigation to patterns (1) addressing the same therapy goals and (2) of the same category; see Figure 11.

### Original design



### Current design

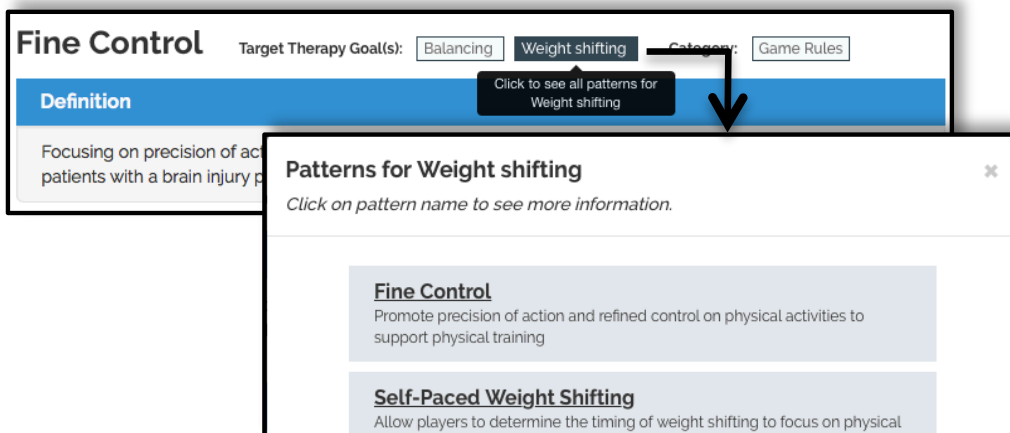


Figure 11. Enhancing navigation in detailed pattern info page

## 6.3.2 Modifying the Background Information Structure

In the initial design, the background information about game design for BI therapy was presented in a separate page and contained sectioned texts. In the early usability test sessions, participants took a long time identifying a requested piece of background information. Many also expressed dissatisfaction about this representation. E.g., one participant mentioned, *“It’s a lot of information and this*

is good information. But it should really be compellingly presented.” Based on participants’ feedback, I made several changes to the background information structure, including: (1) elevating the background information to the homepage; (2) organizing the information into sections with collapsible titles and summarizing the text into bullet points; and (3) adding a narrated video to introduce the background information; see Figure 12 for a comparison of the original and the new designs. These changes were well received in later usability test sessions.

### Original design

About Brain Injury (BI)	Why Use Games?	Why Design New Games?
<p>Brain injury (BI) is recognized as a major health issue in many societies. Approximately 6.4 million children and adults in the US live with a lifelong disability as a result of a BI.</p> <p><b>Causes of brain injuries are varied</b> and include external traumatic events such as car accidents and firearms (i.e. traumatic brain injury), loss of oxygen to the brain (i.e. hypoxic brain injury), and cerebral vascular accidents (i.e. stroke). <b>Individual impacts of a BI are also diverse</b> and can involve a wide range of physical and cognitive disabilities.</p> <p>Because of the wide range of causes and potential impacts from a BI, there are varied recovery paths. As such, therapists must customize rehabilitation treatments for each patient.</p>	<p>It is often challenging to motivate people who have had a brain injury to engage in the repetitive exercises common for rehabilitation. As a result, therapists usually include games in rehabilitation sessions <b>to help make repetitive tasks fun and engaging</b> (i.e., to increase motivation to perform both physical and cognitive rehabilitation exercises).</p> <p>Therapists use varied combinations of commercial-off-the-shelf (COTS) games designed for the general public and games that are specifically designed for brain injury therapy.</p>	<p><b>Commercial off-the-shelf (COTS) games have many limitations</b> to be used for BI rehabilitation. For example, COTS games are often too fast-paced and too challenging for patients with a BI. Further, COTS games are not directly targeting BI rehabilitation goals. It is challenging for therapists to choose appropriate and therapeutically effective COTS games for their patients.</p> <p>On the other hand, most of the current games/systems designed specifically for BI rehabilitation are either experimental or if commercial have not reached a high level of diffusion. A common critique was that <b>many specialized games are not able to provide enough engagement and motivation for patients.</b></p> <p>As a result, designing games for BI rehabilitation is a challenging and vibrant area to explore.</p>

### Current design


**About This System**

- We aimed at supporting game designers create **games for brain injury rehabilitation**.
- In this system, we provide designers with **Game Design Patterns** associated with: (1) therapy goals in brain injury rehabilitation and (2) player experience of patients with a brain injury.
- This system helps designers understand and choose the game design patterns that may support game design and communication of design ideas.

**About Brain Injury**

**Why Therapists Use Games**

**About Game Design Patterns**



00:00 | -01:30

[Browse Game Design Patterns Focused on Therapy Goals](#)

[Browse Game Design Patterns Focused on Player Experience](#)

Figure 12. Revised background information structure



### 6.3.3 Adding “My Saved Patterns” Function

During the usability test, participants expressed a need of function that allows them to organize the design patterns they considered useful into a personalized collection. Participants also mentioned that the ability to “*mix and match*” design concepts and elements is important to support creative design. For example, one participant said:

*“I am always thinking this tool could be something where I can collect ideas – where I can put a bunch of stuff that piqued my interest and might fit together. That way I am weeding out things that I know I don’t want to think about. ... I think design is a very intuitive process. So something that enables me to bounce around ideas would be very valuable.”*

In respond to this type of feedback, I added a “my saved patterns” function. Using this function, users can create and login to their account and save particular patterns to their personalized collection; see Figure 13.

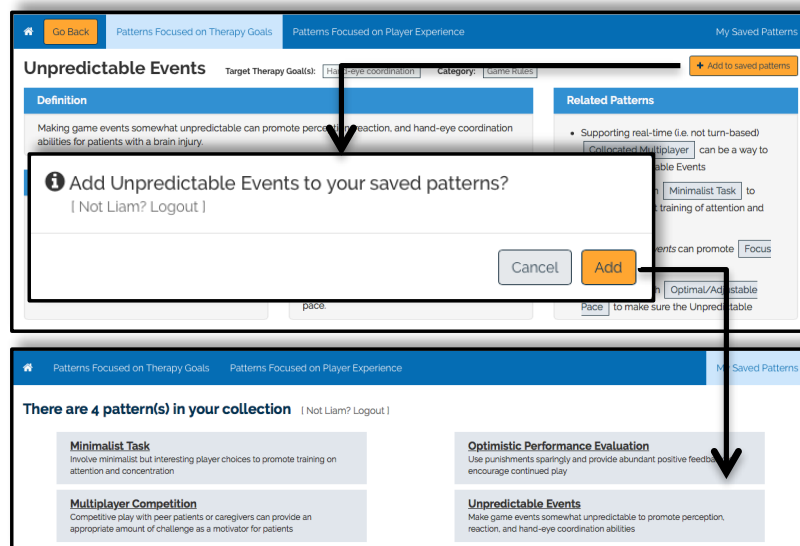


Figure 13. “My Saved Patterns” function

#### 6.3.4 Additional User Feedback

Participants also suggested additional changes to refine the GaPBIT system. Some of the suggestions were regarding the specific wording in the description of the patterns and guided editing of the design pattern documents. A prominent functional suggestion was to add social features that allow users share and comment on the patterns. For example, when looking at the therapists' comments on the example games, one participant said, "*It might also be interesting to see some comments from other game designers here as well – if they have some experience about how to effectively use the pattern – not on the example games, but more on the pattern itself.*" This input will be used when improving GaPBIT in future work.

#### 6.4 Conclusions

GaPBIT leverages the BI therapy game design patterns to support ideation and collaboration in game design. The initial user interface was created based on the structure of the design patterns. The user studies had resulted in various functional and visual modifications of the system. In the next chapter, I describe a set of quasi-experimental case studies intended to further evaluate and user experience and efficacy of GaPBIT in realistic game design workshops.

## **CHAPTER 7. PHASE FOUR: EVALUATING GAPBIT IN GAME DESIGN WORKSHOPS**

After completing the design iterations, I conducted evaluation studies with game designers and therapists in order to further explore user experience and efficacy of the GaPBIT prototype. I first conducted six game design workshops; each represented an experimental condition of a unique game design configuration in which a game designer worked with a therapist and/or used the GaPBIT prototype. I then asked professional game designers and therapists to evaluate the game ideas produced in the workshops. In this chapter, I first outline the methods used in these studies (section 7.1). I then summarize and discuss the game ideas created during the workshops (section 7.2) and present the game evaluation results (section 7.3). The summary and detail findings of the design workshops are discussed in sections 7.4 and 7.5, respectively; in the discussion, I focus on my observations about how GaPBIT influenced the design process. Finally, I discuss the conclusive remarks in section 7.6.

### **7.1 Methods**

The evaluation was based on three main hypotheses: (1) GaPBIT facilitates collaboration between designers and therapists; (2) GaPBIT helps create a game concept that is better perceived by both designers and therapists; and (3) GaPBIT better supports novice designers. In this section, I describe the methods for: (a) the game design workshops aimed to understand the use of

GaPBIT in different design contexts; (b) evaluation of the game ideas produced in the workshops; and (c) the data analysis procedures.

### 7.1.1 Game Design Workshops

I led six game design workshops in July and August 2016. In each workshop, I asked participants to ideate a game (or a set of mini-games) for a given BI therapy scenario and create a two-page written game design pitch to illustrate the game's concept and gameplay. The experimental design of the workshops included three conditions: (1) a designer working with a therapist to ideate the game (*Condition DT*); (2) a designer using the GaPBIT prototype to ideate the game (*Condition DG*); and (3) a designer working with a therapist while using the GaPBIT prototype (*Condition DTG*). Two workshops were held in each experimental condition; one workshop included a professional designer and the other included an undergraduate game design student from DePaul University. A total of six game designers participated in the workshops, including four males and two females. Four therapists also participated in *Conditions DT* and *DTG*. One was an occupational therapist (OT) and three were physical therapists (PT); therapists included two males and two females. All therapists were working with patients with BIs. See Table 3 for a summary of the study design.

For each workshop, I began with an introduction about game design for BI therapy. In *Conditions DG* and *DTG*, I also provided a brief tutorial of the GaPBIT prototype. I then presented the game design requirements, which described a fictional female patient who had a stroke in her 50s and was focused on improving her standing, walking, attention, and concentration abilities; the requirements also specified several hobbies of the patient prior to injury. Workshop participants were then asked to create a game on any platform (either

digital or non-digital). See Appendix E for the material I used in this study. I observed the design sessions from a soundproof room behind a one-way mirror. Workshop sessions were video recorded and were time-limited to 90 minutes. After the sessions, I debriefed the participants about their experience; all debrief interviews were also video recorded and later transcribed.

Table 3. Game design workshop experimental design

<b>Condition</b>	<b>Case</b>
DT (Designer + Therapist)	PD+T: Professional Designer + Therapist (PT) SD+T: Student Designer + Therapist (PT)
DG (Designer + GaPBIT)	PD+G: Professional Designer + GaPBIT SD+G: Student Designer + GaPBIT
DTG (Designer + Therapist + GaPBIT)	PD+T+G: Professional Designer + Therapist (PT) + GaPBIT SD+T+G: Student Designer + Therapist (OT) + GaPBIT

### 7.1.2 Game Idea Evaluation Sessions

I asked three professional game designers and three therapists (one PT, one OT, and one recreational therapist) to evaluate the game design ideas created during the workshops; all evaluators were not involved in the workshop sessions. The evaluation criteria were framed so that the designer evaluators focused on the possible player experience outcomes while therapists focused on the therapeutic value of the games; see Table 4 for a summary of foci in the evaluation criteria for both groups. For each game idea, the evaluators were asked to rate each criterion on a five-point scale and provide an overall score from zero to ten. To mitigate order effects, I counterbalanced the design pitches using a randomized Latin Square [101]. After evaluation, I debriefed the evaluators to discuss the factors associated with the potential success of those game design ideas. See Appendix F

for the material I used in this study. Each evaluation session lasted for an hour; all were conducted over the phone and were audio-recorded.

Table 4. Foci of criteria for evaluating the game pitches

<b>For Designer Evaluators</b>	<b>For Therapist Evaluators</b>
Game goal is clear	Effective for the therapy goals
Feedback is relevant	Difficulty level is appropriate
Mechanics are innovative	Theme is appropriate
Theme is appropriate	Suitable for in-patient therapy
Theme is unique	Suitable for at-home therapy
Game is re-playable	

### 7.1.3 Data Analysis

I adopted an inductive approach to analyze the data [35]. For the design workshop sessions, I first coded the workshop videos in 10-second increments to identify predominant activities and events in each time slice and created a codebook (see Appendix I). Two other researchers then used the codebook and each deductively analyzed three workshop videos. I calculated the percentage of time slots in which the participants' activities were categorized in each theme. I then evaluated inter-rater reliability on these percentage values between the codebook generator and the blind coders using Intraclass Correlation Coefficient (ICC) Model 2 [127, 172]. Additionally, I also analyzed the game design pitches and the debrief interviews to identify common themes.

## 7.2 Game Ideas Created

Although I asked the participants to consider both digital and non-digital games, all design pitches focused on digital games. Among the four cases using

GaPBIT, participants incorporated between four and ten game design patterns in the game design ideas. I summarize each game idea in this section.

*Game Idea PD+T:* Participants designed a Kinect game concept in which the player explores an enchanted garden maze and catches dolls that came to life from the player's collection; during the gameplay, a mystery storyline unveils. The player is required to step to navigate the maze and moves his/her arms to catch dolls and solve various puzzles. The dolls have different behaviors, providing various physical and cognitive challenges. Players and/or therapists can also adjust required movements, the amount of visual and auditory stimulation, and maze complexity level.

*Game Idea SD+T:* Participants designed a concept involving a series of mini-games/activities; each requires either Wii controllers or the Dance-Dance Revolution controller to play. Example activities include a racing game in which the player shifts weight to steer and accelerate and a tower defense game in which the player steps in different directions to move the cursor and place structures. Some activities allow players or therapists to adjust the required movements.

*Game Idea PD+G:* The professional designer used GaPBIT to create a concept based on adult coloring activities. Players are required to stand and use a baton paintbrush to complete images on a big screen by adding textures and colors. The images were curated to the player's taste and interest. Upon full or partial completion of an image, an animation effect activates based on the player's work. At the start of the game, players can adjust the boundaries of play space based on their range of motion.

*Game Idea SD+G:* The student designer used GaPBIT to design a concept that uses the Wii Fit balance board in which the player experiences the growth of a flower. The game starts with the player shifting weight to allow a bud to gather sunlight; more complex mechanics that involve arm movements to control the

leaves are introduced as the game progresses and the flower grows. The game also provides different adjustable modes, imposing various levels of challenges.

*Game Idea PD+T+G*: Participants used GaPBIT to create a concept using the Wii Fit balance board in which players cycle in increasingly complex environments, collecting items to unlock new areas to explore. The player is required to shift weight side to side to pedal and to steer using a stand that resembles a bicycle handle supporting two Wii remote controllers. Players or therapists are able to adjust the required movements, the amount of visual and auditory stimulation, and the speed of the game.

*Game Idea SD+T+G*: Participants used GaPBIT to create a concept involving a series of Wii mini-games based on activities in Yellowstone National Park. Example mini-games include: Log-Balancing, in which the player shifts weight to keep the avatar on a wooden log while crossing a river; and Bird Watching, in which the player shifts weight to move binoculars looking for a certain kind of bird and holds the position to take a picture. Each mini-game introduces additional movements and puzzles as it progresses. Players or therapists can adjust the required movements and the amount of visual and auditory stimulation in the game.

The six game ideas reflected characteristics of the experiment conditions. For example, the two games designed without a therapist (*Condition DG*) embodied a more artistic quality, while the games designed with a therapist (*Conditions DT* and *DTG*) integrated more challenging physical and cognitive activities. Additionally, both games designed by student designers working with a therapist (*Game Ideas SD+T* and *SD+T+G*) adopted a mini-game structure, while all other ideas focused on stand-alone games. These observations indicated that the therapists' inputs during the game design process had a great influence on the final game ideas. The therapists provided valuable information about the needs in



BI therapy that resulted in richer game mechanics. However, novice designers may have had difficulty absorbing the complexity of information provided by the therapists, resulting in creating less coherent gameplay. The student designer from *Case SD+T* mentioned in debrief, “*At first we wanted to focus on one game. But it’s hard to do too much in one activity. ... [The therapist] just provided a lot of different considerations you have to worry about.*”

Notably, all six game ideas allowed players and/or therapists to adjust certain game features; many also provided an easy starting level and a slow learning curve. Adjustable features to address a wider range of patient abilities are commonly desired by therapists who use games in BI therapy [7, 152]. Without a therapist, GaPBIT was able to communicate this need through the design patterns such as *Self-Paced Weight Shifting* (see A.1.4), *Adjustable Speed* (see B.2.1), and *Optional High-Level Challenge* (see B.1.2). In the cases including a therapist, however, the adjustable features were more emphasized and contained more details.

### **7.3 Game Idea Evaluation Results**

Figure 14 summarizes the average overall score (out of ten) that the designer and therapist evaluators gave for each game idea. Notably, for the cases in which student designers worked with a therapist, the game idea achieved considerably higher score from both designer and therapist evaluators when created using GaPBIT (*SD+T+G*) than when created without GaPBIT (*SD+T*). In contrast, for the cases in which professional game designers worked with a therapist, game ideas created with and without GaPBIT (*PD+T* and *PD+T+G*) were rated similarly. This result indicated that the GaPBIT prototype could potentially benefit novice designers more than professionals.

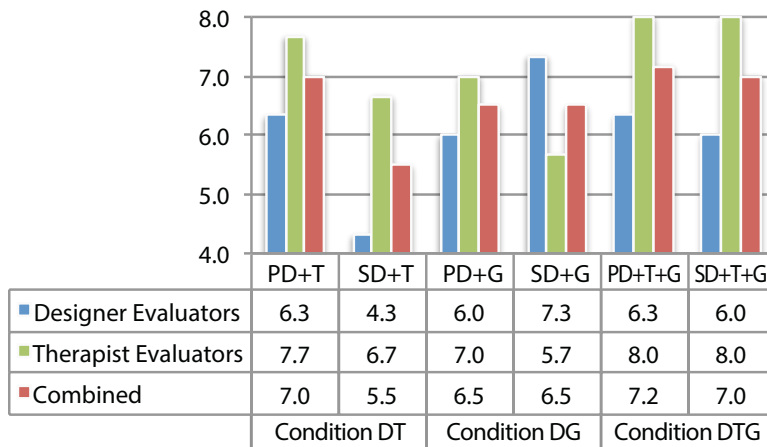


Figure 14. Average overall score for each game idea

The therapist evaluators rated the game ideas created in *Condition DTG* (designer + therapist + GaPBIT) as the highest. They thought those two game ideas were particularly suitable for inpatient use (an average score of 4.7 out of 5 on that criterion) because they both presented a wide variety of adjustable physical and cognitive challenges. *Idea SD+G* (student designer + GaPBIT) was rated as the lowest by the therapist evaluators because of its oversimplified theme and inability to provide adequate challenge for target patients; e.g., one evaluator said, “*I think there is just not enough in the game. It might be nice for a very low-level patient who is just starting to work on their standing balance, but it seems like that the target group is higher level than that.*” See Figure 15 for details about the therapist evaluators’ ratings.

Conversely, designer evaluators rated *Idea SD+G* the highest; they praised its minimalist design and the metaphor of growth in the game. For example, one evaluator said, “*It’s pretty elegant. It’s not terribly complex but it does feel complex enough to be engaging. ... And the metaphor of growth is very nicely embedded.*” *Idea SD+T* (student designer + therapist), on the other hand, was considered the least impressive among the designer evaluators mainly because it

lacked innovative elements (the criteria “the mechanics are innovative” and “the theme is unique” were rated as 1.7 and 1.3 out of 5, respectively) and did not have a coherent theme across the activities. See Figure 16 for details about the game designer evaluators’ ratings.

The discrepancy between the therapist and the designer evaluators on *Idea SD+G* demonstrated conflicting interest between the two groups. While this difference of interest is understandable because game designers and therapists have disparate foci and considerations about games for BI therapy, it poses a particular challenge in the design and evaluation of these and other types of serious games for health. This finding highlighted the need for these two groups to achieve mutual understanding in order to create games that can both meet the goals of engagement and be effective at addressing therapy goals [27, 28].

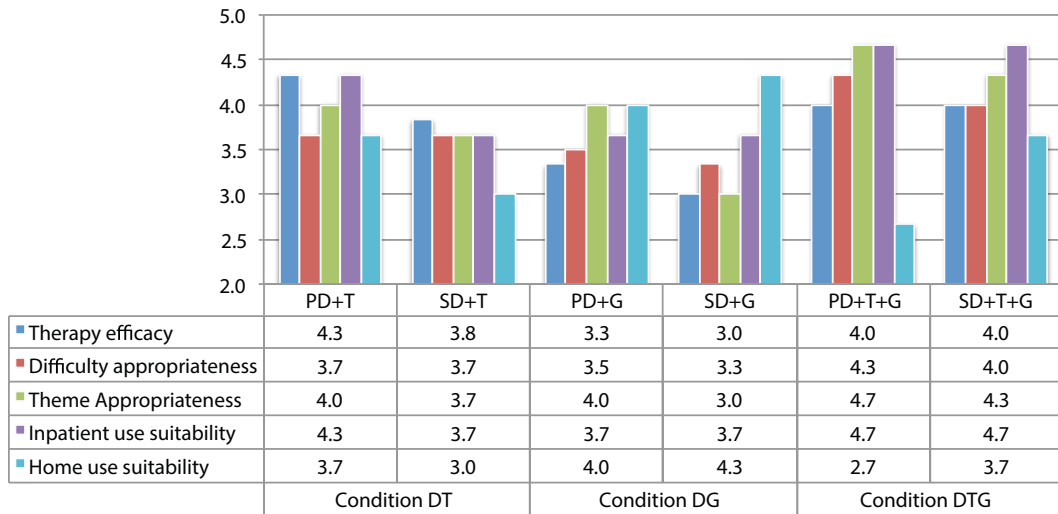


Figure 15. Therapists’ evaluation of the game ideas on the five criteria focusing on efficacy and appropriateness

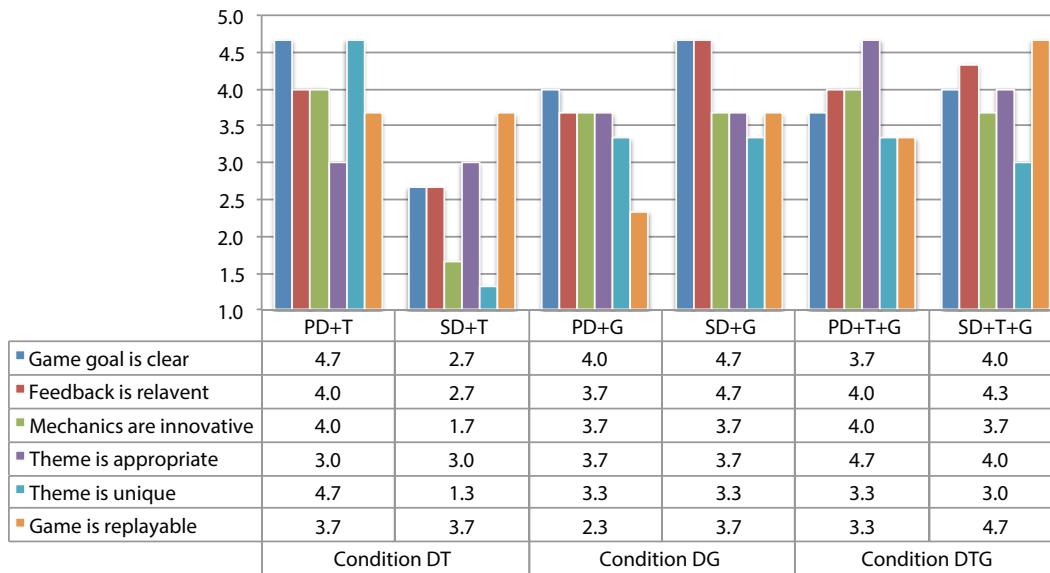


Figure 16. Game designers' evaluation of the game ideas on the six criteria focusing on player experience outcomes

## 7.4 Game Design Workshop Sessions Summary

Recall, I coded the workshop videos in 10-second increments and evaluated inter-rater reliability using ICC2. In this section, I only report on themes in which inter-rater correlation was considered statistically significant based on F-test with an alpha level of .05 [127]. Among those themes, the mean ICC was .886 ( $SD = .101$ ); an ICC measure of 0.7 or higher is considered a strong agreement.

### 7.4.1 Major Activities

The game design workshop sessions lasted between 40 and 106 minutes (see Figure 17). I identified six major categories of activities the participants performed during the design workshops: (1) reading the design requirements handout; (2) taking notes or sketching; (3) communicating or discussing (if a therapist was involved in the workshop); (4) using GaPBIT (if the GaPBIT

prototype was involved in the workshop); (5) typing or editing the design pitch; and (6) thinking in silence or talking to self. Figure 18 summarizes the percentage of time the participants spent in the six major activities.

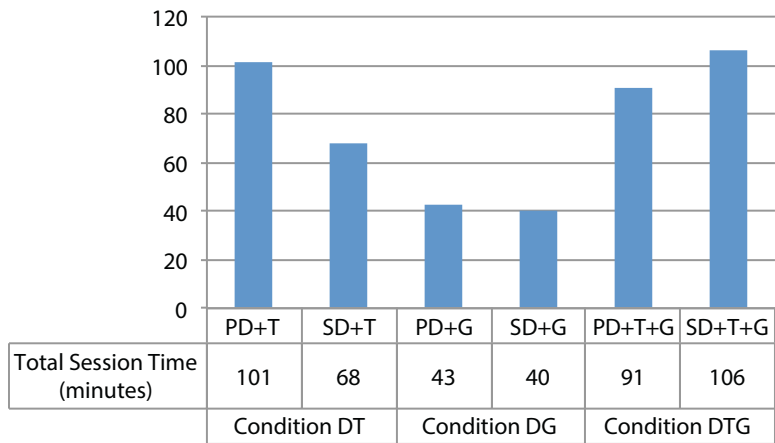


Figure 17. Total time spent in each design workshop session

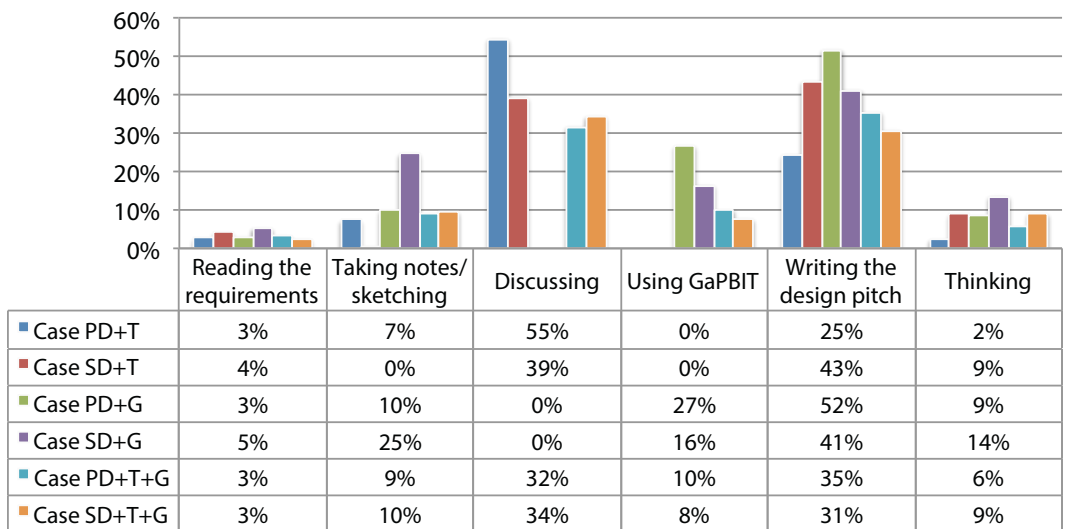


Figure 18. Percentage of time spent on major activities

### 7.4.2 Designer-Therapist Discussion

When a therapist is involved (*Conditions DT* and *DTG*), I identified several prominent events during the discussion between the designer and the therapist; those events were attributed to the individual participants and included: (1) asked a question to acquire information; (2) suggested a game design idea; and (3) voiced disagreement or concern. During sessions when GaPBIT was used (*Condition DTG*), therapists provided more game design suggestions and both the therapist and the designer voiced considerably less disagreements or concerns (see Figure 19).

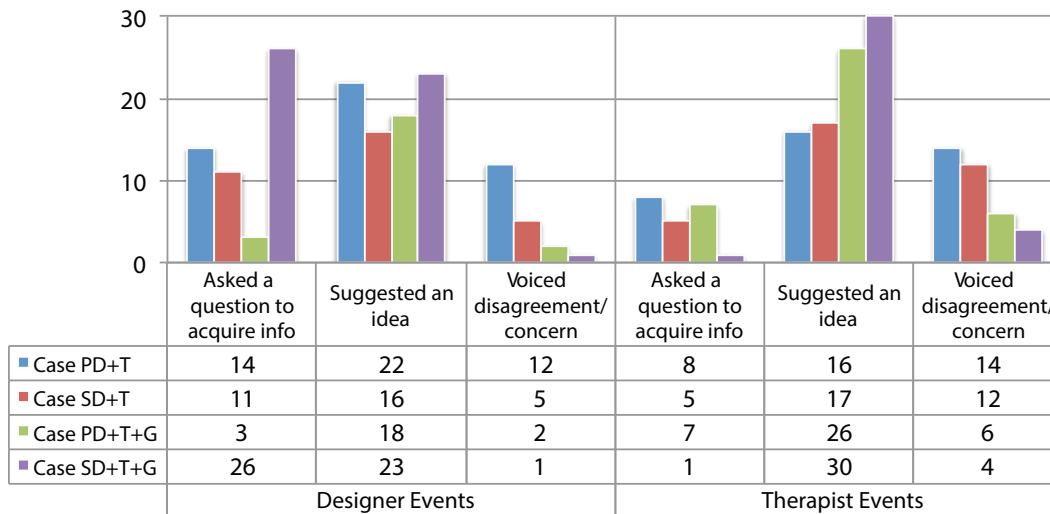


Figure 19. Counts of designer and therapist discussion events

Further, when GaPBIT was not used, the discussion around disputable issues was rather intense. E.g., in *Case PD+T* the participants had a heated discussion about adjusting the game’s challenge level after the designer wrote, “the maze will start simple and get more challenging”:

*Therapist:* Does that statement there mean that we can change the variables for the maze? ...

*Designer:* [hesitantly] Well, if the complexity could be changed... then it would probably be a procedurally generated maze. I don't know how that'd work...

*Therapist:* I mean the maze can get a little harder each level. That's fine. But maybe in one level, as far as the cognitive layers we've been discussing ...

*Designer:* Well, as far as the actual mechanics, you could go with something that is completely flexible, but then I'm essentially giving you a toolbox and say, "put it together." Then you'll have to be the game designer and determine the challenge. Alternatively, we could design a learning curve that we decide would make a good puzzle. But it is what it is. I mean it's possible to do it either way, but I think it'd put a big burden and take a lot of time for a therapist to set it up.

*Therapist:* Well. I am just thinking it would be nice like when she is on level one and she needs to find five dolls in ten minutes, and it is taking her six minutes to get the first one. ... So it would be nice if I could pause it and change the objectives a little bit. Or if she's been super distracted by all the birds that fly by, I can get rid of some of those things. ...

Eventually, they both made compromises and agreed to include only certain types of adjustable variables. In *Condition DTG*, I did not see this type of intense discussion. This indicated that the design patterns included in GaPBIT helped both the designer and the therapist realize the potential issues early, resulting in more efficient discussion.

To further examine the quality of discussion between designer and therapist during the design sessions, I separated eight major categories of discussion among designers and therapists:

- *BI therapy practice*: Participants discussed general goals and typical practice of BI therapy. For example, at the start of Case PD+T, the designer asked the therapist: “*How does training attention have been incorporated in your therapy? How do you deal with that in your practice?*” The therapist then explained how he had to isolate a patient from the noisy environment of the gym at first and slowly introduce external stimuli to help the patient regain concentration abilities.
- *Target player attributes*: Participants discussed target player attributes from the scenario; attributes included physical and cognitive abilities, and/or taste and interest. For example in Case SD+T+G, after reading the patient description the therapist explained his interpretation: “*Cognitively she is probably higher level. Her speech is probably okay as well. And she can understand sequential commands, which is a good sign for rehab.*”
- *Game – High-level concerns*: Participants discussed high-level design considerations for the proposed game. For example in Case SD+T+G, during an early stage of design the therapist said, “*We need to keep it simple, being able to customize without taking too much time – in the world of rehab, time is the biggest issue...*” They then started elaborating the game parameters needed to be adjusted.
- *Game – Platform/controller*: Participants discussed which game platform and/or controller to use. For example in Case SD+T, the therapist declined the designer’s suggestion to use Kinect: “*The problem with Kinect is that if they need support to stand, I can’t be there because it picks me up.*”



- *Game – Fictional layer*: Participants discussed designing the game’s genre, theme, and/or story. For example in Case PD+T, the designer proposed the enchanted garden idea and expressed willingness to include a storyline, then the therapist suggested the idea of using a garden maze to promote problem solving.
- *Game – Core mechanics*: Participants discussed designing the core mechanics of the game (i.e. the essential play activities players perform repeatedly in a game [165]). For example in Case SD+T+G, participants first came up with a set of activities around the National Park theme and then discussed the core mechanics in each activity.
- *Game – Features/variations*: Participants elaborated the game design idea and discussed the game’s additional features. For example in Case PD+T+G, the designer suggested the idea to use music as an indirect reward: “*It could be that the music plays with more instruments if you go faster – as a ‘non-essential’ reward for moving faster.*”
- *Design patterns*: When participants used GaPBIT, they discussed which design patterns to choose and how to incorporate the patterns in their game. For example in Case PD+T+G, participants reviewed each design pattern they had “saved” to their library and discussed how to incorporate them in their game.

### 7.4.3 Design Phases

Based on participant activities and discussion, I divided each design session into three high-level phases. The first was an **Exploration Phase**. All design sessions started with participants reading the requirements document. The participants then explored the problem and solution spaces of game design

through discussion and/or using the GaPBIT prototype. Initial discussion topics were usually about BI therapy practices and the target player attributes; discussion then shifted to topics about high-level game design considerations, the game’s platform or controller, and its core mechanics. Next came the **Elaboration Phase**. When a core idea of the game is settled (indicated either in written notes or verbal discussion), participants took extensive notes and focused on expanding the game’s core mechanics and theme; the discussion topics covered all categories and were mainly focused on the game’s fictional layer and its features and variations. Last, the design process moved into a **Finalization Phase** when participants started writing the design pitch. While mostly focused on typing and editing, participants also refined their design ideas during the finalization phase. See Figure 20 for a summary of percentage of time participants from each case spent on the game design phases.

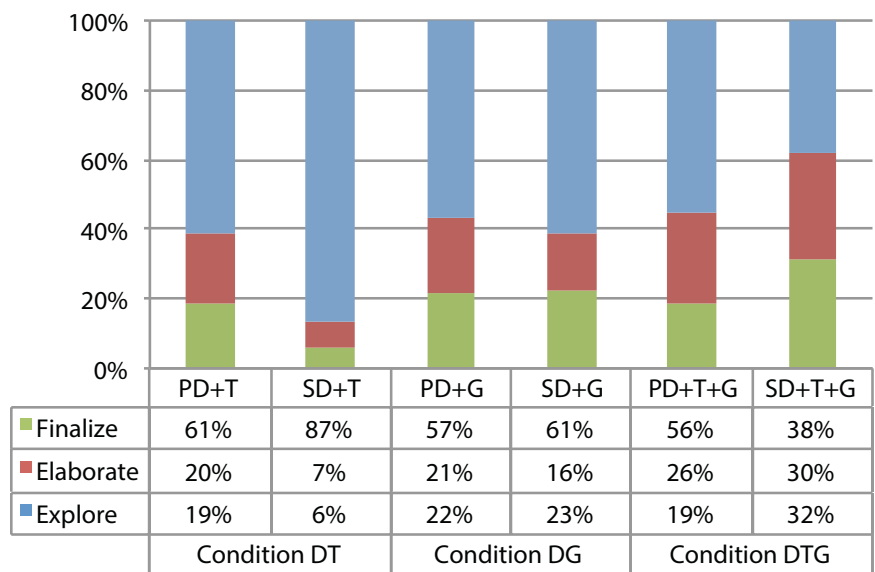


Figure 20. Percentage of time participants from each case spent on the game design phases

The GaPBIT prototype was used most frequently in the Exploration Phase (See Figure 21), in which participants explored various design patterns and regularly “saved” patterns into their library; when a therapist was involved (*Condition DTG*), GaPBIT helped frame the discussion about the high-level design considerations and the game’s core mechanics. In the Elaboration and Finalization Phases, participants revisited those saved patterns seeking clarification and inspiration for game design ideas; the discussions about the game’s features and variations were usually shaped by patterns in GaPBIT. For example, at the start of the Elaboration Phase of *Case PD+T+G* the participants explored several design patterns they had saved and discussed how to incorporate them in the game:

*Therapist:* Since she [the patient] is a cycler, maybe we can use some platform that she can hold on to, allowing her to stand and shift weight side to side to mimic that.

*Designer:* Yeah. With “*Moving Different Body Parts*”, I think we can integrate the balancing with the hand motion to pick things up, to collect things. ... And it also goes with “*Self-Paced Weight Shifting*”. ... I think the motivation to continue playing would be that you go farther and you see new things, instead of like you are trying to beat a certain distance. ...

*Therapist:* Yeah. And just in terms of “*Focus and Distraction*” and increasing the level of difficulty, it could be just about the setting. She could start out in a very non-busy area and go to more maybe...

*Designer:* Like a meadow into a forest, then into a city.

*Therapist:* Yeah. And sound-wise too.

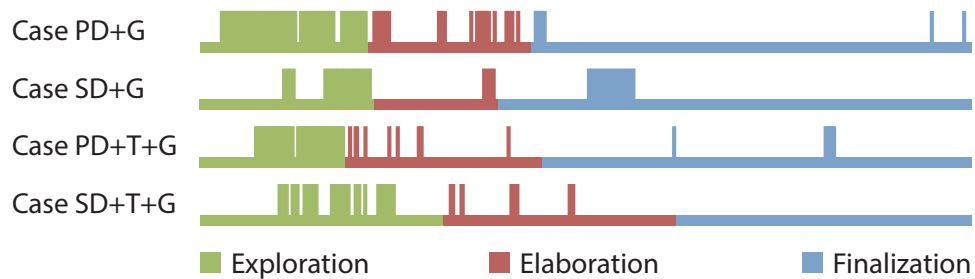


Figure 21. Frequency of GaPBIT use by phase. Each vertical bar indicates a time slot in which GaPBIT is used.

#### 7.4.4 Workshop Participants' Feedback

While participants in all conditions stated that they were satisfied with their game ideation process, the reasons for satisfaction varied. In *Condition DT* (designer + therapist), participants valued the interaction with someone from an unfamiliar field to bring in different perspectives. For example, the therapist from *Case PD+T* mentioned, “*It’s nice to talk to someone in a completely different field because you can bounce ideas off of each other and get other ideas from a different point of view.*” The student designer from *Case SD+T* also mentioned, “*I did learn a lot about the things therapists do and consider that I would not thought of. ... [The therapist] didn’t seem like she is worried about voice of concerns, which is always a good thing.*”

In *Condition DG* (designer + GaPBIT), the designers thought the GaPBIT prototype were useful at helping them explore game design ideas and understand the needs in BI therapy. For example, the professional designer in *Case PD+G* mentioned, “*I came with the idea very early on and I think from the tool I got just enough support without being overwhelmed.*” The student designer in *Case SD+G* also said, “*When making games I don’t often think about players who have a*

*disability. ... So the tool did help me single out the things I am looking to the needs of this particular group.”*

In *Condition DTG* (designer + therapist + GaPBIT), participants also commented on the common language that GaPBIT provided to support communication for the designer and the therapist to create a game as a team. For example, when asked how he felt about interacting with the designer, the therapist from *Case SD+T+G* said:

*“I think the tool did open up that communication where you have two experts in very different areas trying to come up with something that they have to work together on. It captured a lot of the terms we use and the goals that we have. So I think it helped the game designer talk in our terms.”*

The therapist from *Case PD+T+G* commented on the value of example games: *“I think having the examples currently exist out there at the bottom of each pattern is very useful. ... Like the example of the weight-shifting one, they have the Wii Table Tilt, which I used in with patients – that sort of gave him some concept of my side of things.”* The designer from *Case PD+T+G* also mentioned: *“The tool acts as almost a checklist. So it helps to have someone else view it and also to hear their understanding of how each thing could be addressed.”*

## **7.5 Game Design Workshop Session Details**

In this section, I present details from each game design workshop session. I especially discuss my observations about their design process, how they used GaPBIT (if the prototype was included) and their discussion structure (if a therapist was involved).

### 7.5.1 Case PD+T (Professional Designer + Therapist)

The professional game designer in *Case PD+T* had worked for over eight years creating digital games for health, especially digital games that promote awareness of anxiety and depression. During the game design session, she worked with a physical therapist who had used video games in therapy. Figure 22 and Figure 23 illustrate the major activities the two participants performed as a team and the topics they discussed over the design workshop timeline.

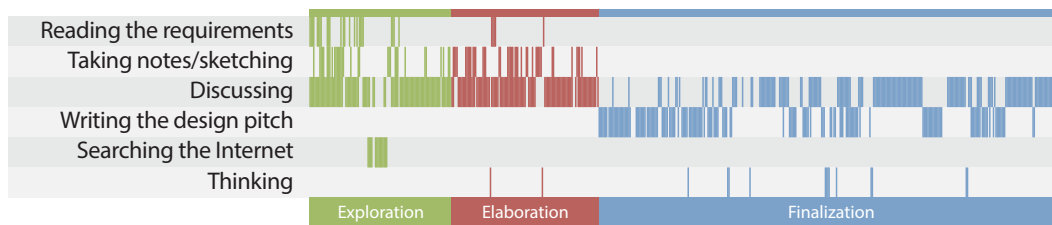


Figure 22. Major activities of participants from *Case PD+T*

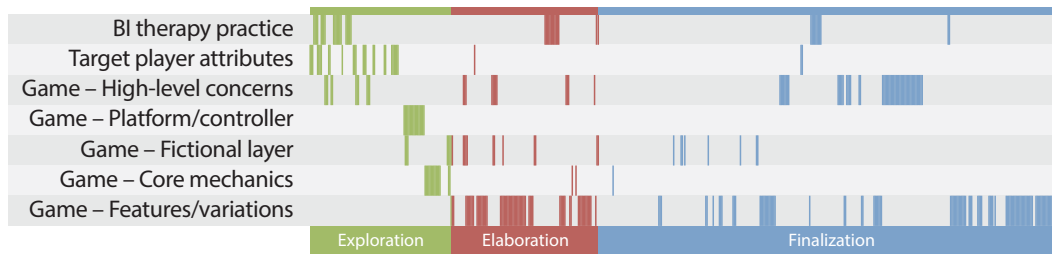


Figure 23. Discussion topics between participants from *Case PD+T*

The session started with the two participants reading the design requirements together. The therapist then took initiative to explain therapeutic considerations associated with the target player, saying: “*The whole idea of rehab after a brain injury is trying to influence neuronal plasticity. So she has to force herself to use that arm and that leg over and over, so that the brain can remember*

*how to do it correctly – she needs to force herself to use it to work on that strength and coordination.”*

For the first half of the *Exploration Phase*, the discussion was mainly focused on typical therapy practice, activities that can address the target player’s impairments and therapeutic needs, and how to cater the target player’s taste and interests. For example, the following discussion transited from therapist’s practice to the target player’s interests and finally resulted in some high-level game design considerations for their game idea:

*Therapist:* When you work with the brain, you need to engage the person and gain their attention. ... If all that you do were just repetitive and not engaging, they would not be able to carry it over. That’s why when we were using video games, we want to have the patient to try to do things that kind of mimic real life as much as possible – because it is more engaging; it is more like something they will have to do everyday.

*Designer:* Well. The “mimicking real life” I think is particularly useful in creating exercises about what they do in real life. But it seems like there is a strong fantasy component in her profile. She seems to have a vivid imaginary life. She is an “active reader and writer.” So she might respond well to something that also simulates fantasy and imagination.

*Therapist:* Yeah. That is true. That is a good observation.

*Designer:* Because very often if you go too literal it wares off very quickly. ... So if we introduce some kind of mystery or some kind of story element in the game, she will probably receive it better.

During the exploration phase, the participants also searched the Internet to explore games the target user enjoyed playing. They then spent a very concentrated time frame to decide on the game's platform; they eventually chose the Xbox Kinect as their target platform. Finally, they determined the game's theme and core mechanics: collecting antique dolls in an enchanted garden maze; this demonstrated the end of the exploration phase.

During the *Elaboration Phase*, the participants brainstormed possible variations based on the game's core mechanics; for instance, they explored ways to involve arm movements and auditory cues in mini-puzzles included in the game. During this phase, the need of "adjustable features" also emerged when participants discussed level design:

*Therapist:* As her attention gets better, her balance gets better, and her endurance gets better, she is able to do more. She will need more challenge. But this needs to be controlled. ... And something we noticed when using the Kinect, roughly in any video games is that those games are made for the general population – the healthy adults instead of people with brain injury. So it would be nice if we could go in and customize and adjust the levels. ... Like you start off and found it is too difficult for her. Then you could pause the game and reduce the number of dolls she has to find or ...

*Designer:* Okay. So variables. Let's just write those down.

*Therapist:* Yeah. Adjustable variables.

*Designer:* Yeah. So number of dolls, behavior of dolls, intricacy of the maze, and...

*Therapist:* And maybe the time limit.



The designer took extensive notes during the exploration and elaboration phases about thoughts emerged from the discussion (see Figure 24).

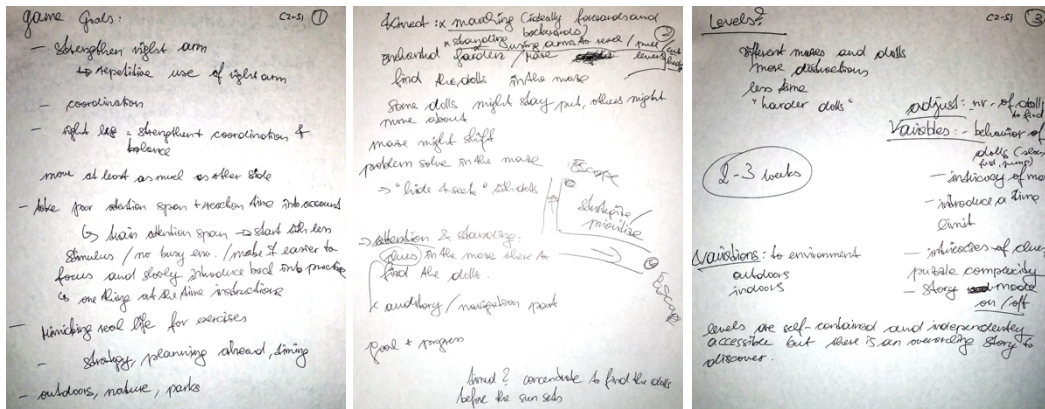


Figure 24. Notes taken by the designer from *Case PD+T*

The *Finalization Phase* began when the designer started to type and edit the game design pitch. However, during this phase the designer and the therapist were still involved in extensive discussion on several crucial high-level concerns of game design; those concerns included how adjustable features should be implemented (see section 7.4.2), how to show player performance in an encouraging and therapeutically meaningful way, and how to consider the game storyline in inpatient therapy contexts. Concerning the last two points:

*Designer:* There is always that tension: do you count on “contingent engagement” or people want to engage with it because they want to know how it ends. So the story is part of the motivation to play and come back to it. ...

*Therapist:* Yeah. I think the bigger story is nice. ... But in therapy there are tools that you use to measure balance, walking, and other things – like all kinds of research, there is a pre-test baseline and there is a

post-test. So like if you do the first level on day one and you keep playing the game. And maybe right before the patient leaves the hospital, you can go back and play level one again to see how she improves. ...

*Designer:* Right. And it is not about figuring out the mystery. It is about being able to do the physical part.

*Therapist:* Exactly.

*Designer:* Yeah. So it is nice to have a story, but the story is not the most important thing. And you should be able to still get the physical part. Yeah. That's a good point.

The design session concluded with a discussion about further possibilities to include adjustable features in the game; the designers acknowledged the feasibility of those features but did not include them in the pitch. Highlighting the challenge of creating games for BI therapy, the designer said in the debrief interview:

*"I thought that there was a good back and forth of information and it was very flexible to get missing information through discussion. ... But then there was always a frustration of 'Okay, we have to think this through more.' And this is just the tip of the iceberg and there are all of these problems that came up with in the discussion: How flexible this is needed to be? What is the reality of the therapy setting? It just takes a lot of back and forth. And things, as a designer, don't occur to you to ask – because we all come in with our assumptions, which are usually wrong."*

### 7.5.2 Case SD+T (Student Designer + Therapist)

The student designer in *Case SD+T* was a junior-year undergraduate student in the game design program at DePaul University; he had a background in game programming. The physical therapist participated in this session had used video games in therapy sessions but was not very experienced in using technology. Figure 25 and Figure 26 illustrate their major activities and their discussion topics across the design workshop timeline.

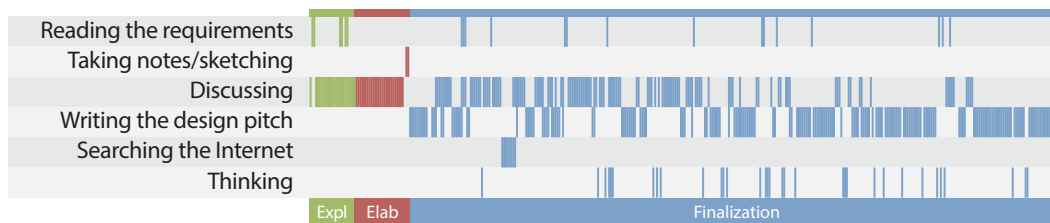


Figure 25. Major activities of participants from *Case SD+T*

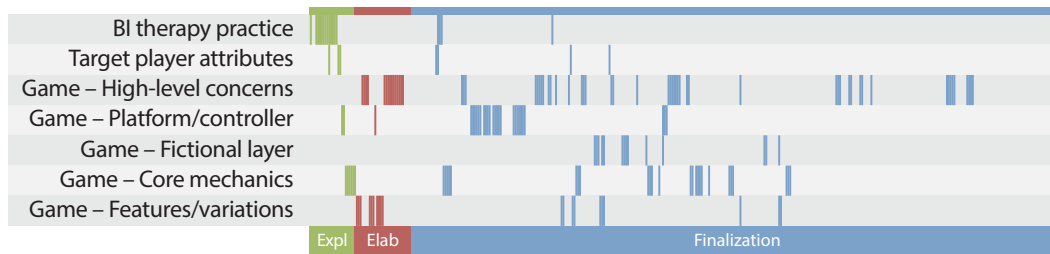


Figure 26. Discussion topics between participants from *Case SD+T*

Similar to *Case PD+T*, the session started with the two participants briefly read the design requirements. Then the designer prompted discussion about current therapy practice by asking, “*If you had a patient like this, what would you recommend them to do?*” When the therapist began talking about what games she might use with the patient, the designer dragged the topic back to typical rehabilitation: “*Not only to think about games. What would you do normally when*

*you have this patient in your therapy room?”* The therapist then was able to provide information about rehabilitation activities.

Notably, the *Exploration Phase* and the *Elaboration Phase* were very short in this design session. In the *Exploration Phase*, the participants only briefly discussed the therapist’s typical practice and the impairments of the target player before jumping into determining the game’s controller and core mechanics: a painting game using the Wii remote control. This short discussion did not allow the designer to acquire enough information about BI therapy in general and the patient attributes in particular to understand the high-level issues he needed to consider in order to form a coherent design plan. To exacerbate the impact of the limited discussion, the designer took very little notes throughout the design session.

In the *Elaboration Phase*, the therapist brought up the idea of adjustable features, saying, “*We need to have the painting to have varied degrees – whether they are able to do a lot of detail or not ... and provide options we can choose based on different age group, interest, and ability.*” The therapist also raised concern about whether this painting activity would be engaging for patients: “*I guess my only thing is like how this is different than just doing an arts and crafts project.*” She then proposed that the game could provide a wider range of motion and include accessories that provide different grips of the remote to help patients who have limited finger coordination. The participants then started writing the design pitch with this premature game idea.

Because of the limited discussion in the exploration and elaboration phases, participants had to make a lot of design decisions during the *Finalization Phase*, while they were typing/editing the design pitch. Soon after they started typing, the participants realized that some of the therapy goals and considerations

were not covered in the painting game; as a result, they started to think about including several mini-games/activities:

*Therapist:* I am not trying to abandon the coloring game. But we can cover the other aspects probably by including a different game.

*Designer:* Yeah. Maybe it could be an environment where there is more than one activity.

However, they realized this situation too late to create a coherent theme for the mini-games/activities they want to include. In their final design pitch, they eventually included this set of mini-games/activities: (1) a painting game using Wii remote controller, (2) a Blackjack card game played using Wii remote, (3) an activity that player stands on a Wii balance board to dodge items falling from above, (4) a tower defense game that is played using the Dance-Dance Revolution controller, and (5) a racing game in which the player shifts weight to steer and accelerate. They were not able to fully elaborate any of the games/activities to include much design details. I speculated that the missteps the participants made during the design session were associated with the lack of experience of the novice game designer. Dealing with the unfamiliar game design task while trying to absorb the complexity of information provided by the therapists exacerbated the challenging situation for the novice game designer.

### 7.5.3 Case PD+G (Professional Designer + GaPBIT)

The professional designer in *Case PD+G* had worked for over three years creating games for health, especially board/card games that support adolescent sexual health. She had also participated in the phases one and three of this study, so she was fairly familiar with the concept of game design patterns and the GaPBIT prototype. Figure 27 illustrates her design workshop timeline.

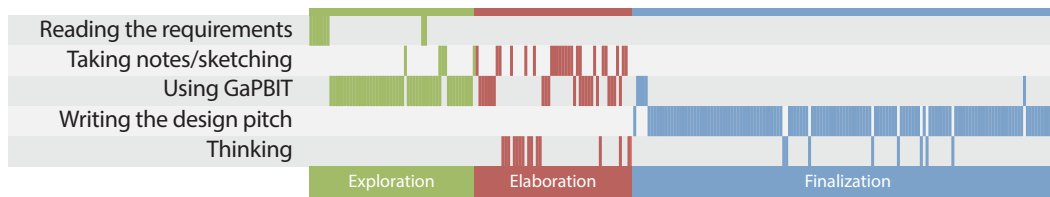


Figure 27. Major activities of participants from *Case PD+G*

In the *Exploration Phase*, she first read the design requirements and then explored several game design patterns using GaPBIT. She extensively focused on the efficacy-centered patterns and saved four patterns: (1) Focus and Distraction, (2) Integrated Standing Duration, (3) Minimalist Task, and (4) Self-Paced Weight Shifting. Particularly, she used Integrated Standing Duration as a “hub” and explored patterns related to it; Integrated Standing Duration focuses on the standing goal specified in the design requirements. Further, during this phase the designer did not explore the example games listed with the patterns; instead, she focused on understanding the solutions proposed in the patterns. After exploring the patterns, she started sketching a painting space on the paper, indicating the formation of the game’s core idea: an adult coloring game. I considered this as the end of the exploration phase.

During the *Elaboration Phase*, the designer continued sketching and revisited the four patterns she saved. In addition to reading the pattern’s definition and descriptions, she explored several example games associated with the patterns. She also took notes about how to implement the patterns in the game (see Figure 28). After she started typing the design pitch (*Finalization Phase*), she also revisited several patterns in search of clarification.

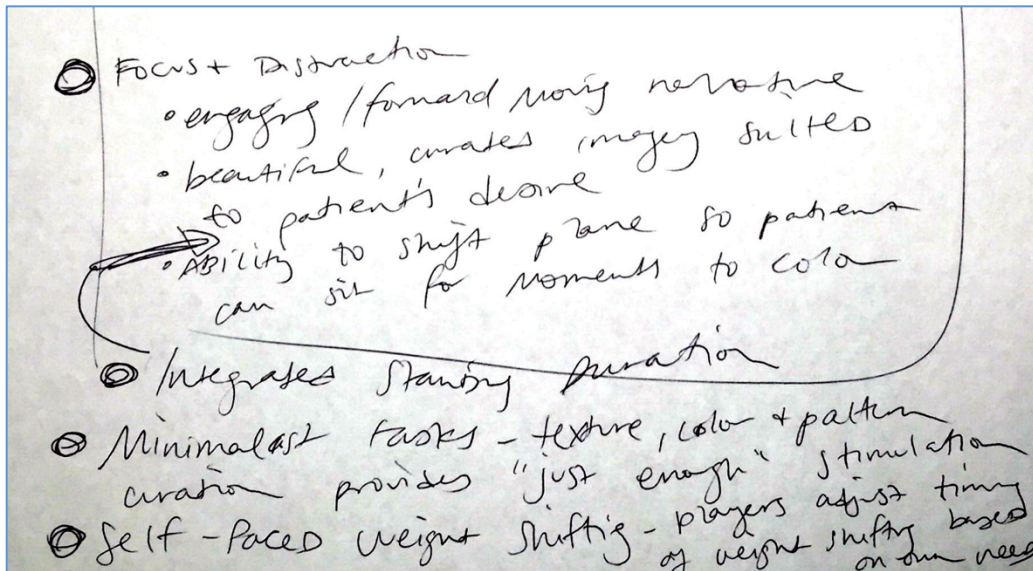


Figure 28. Notes about game design patterns taken during the elaboration phase of Case PD+G

The designer was extremely satisfied with the design process. Once I entered the room for debriefing, she said, without prompt, *“It’s so awesome. I am serious. I can see myself using it personally. I can see it’s being so useful in a student’s context. It’s really neat.”* When I asked about how useful the GaPBIT was at helping her ideating the game, she said:

*“If you had just handed me this [the design requirements], I would not have known where to begin designing the game for it. And I could see myself going down a wrong direction for a long time. I think it [the tool] just got me into this. I feel proud of this game. You know what I mean? Like I feel it’s really successful. ... And that happened in less than an hour. So it feels really satisfying, honestly.”*

When asked about how she used GaPBIT, the designer said:

*“I found myself surprised that I actually was using the example games more than I was expecting to. I think these, the problem and solution, were what I was taking the most notes on. And I made goals for myself around which problems I most want them to tackle based on the therapy goals. They were pretty aligned with the patterns. So it’s pretty straightforward. But when I was picturing the ways in which players interact with their full body in the example games here. I was trying to create a similar environment that would access different learning styles than the ones that are already given. So I was mostly picturing the physical body and the example games and try to mirror something like that.”*

About improving the GaPBIT prototype, she suggested to include a search feature for the example games and provide gameplay videos for those examples.

#### 7.5.4 Case SD+G (Student Designer + GaPBIT)

The designer in *Case SD+G* was a senior-year undergraduate student in the game design program at DePaul University. He was not familiar with game design patterns prior to the study. Figure 29 illustrates his design workshop timeline.

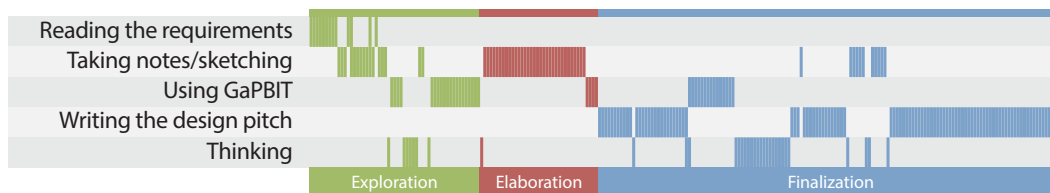


Figure 29. Major activities of participants from *Case SD+G*

During the *Exploration Phase*, he first read the design requirements and took notes about the target player’s therapy goals, physical and cognitive abilities,



and interests. He then used GaPBIT to browse through several efficacy-centered patterns, including Fine Control, Self-Paced Weight Shifting, Change Hands, and Step by Step. It is worth noting that after reading several patterns the designer stood up and imitated the physical disability of the target player by walking around, putting very little weight on his right side (see Figure 30). I speculate that some of the patterns had informed him of considerations about creating games for people with a disability. After exploring the patterns, the designer started sketching a flower on paper, indicating the formation of the game's core idea: a game in which the player experiences the growth of a flower. I considered this as the end of the exploration phase.



Figure 30. The game designer from *Case SD+G* imitated patient impairment

In the *Elaboration Phase*, the designer mostly sketched and took notes to expand the game idea (see Figure 31). He also referred to several patterns such as Self-Paced Weight Shifting and Focus and Distraction. He then began writing the design pitch, indicating the start of the *Finalization Phase*. During this last phase,

he also spent several minutes using GaPBIT to look for more patterns for confirmation and inspiration. He seemed quite absorbed in the design process, saying to himself, “Okay, I got a good concept.” and “I really like this idea!”

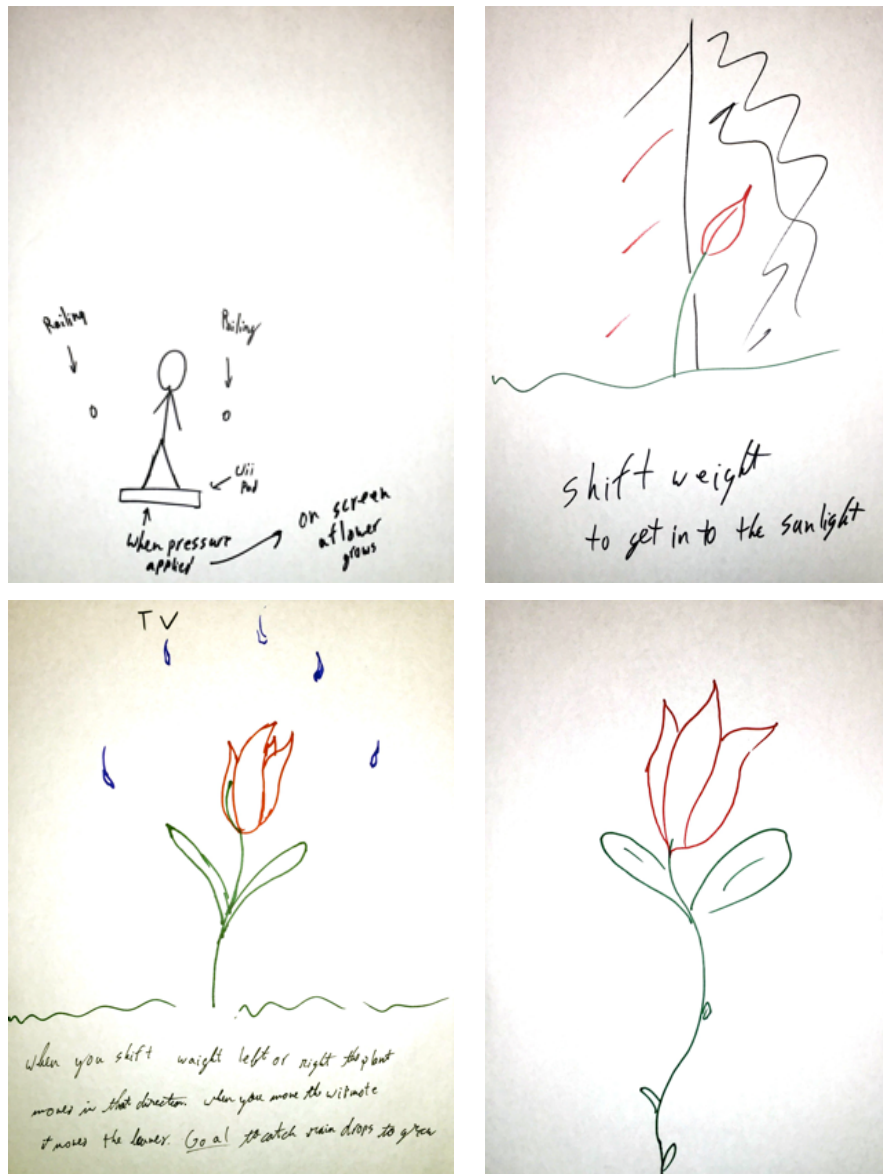


Figure 31. Sketch and notes created by the designer in Case SD+G

In debrief, he further explained his idea of using cheerful visuals and leveraging the metaphor of growth in the game:

*“I figured bright and colorful visuals based on the games she played. And also it’s a game to help people to recover. So you want something bright and cheerful – something that will give them hope. ... It will also keep your attention – because she is having attention issues... And every time they play the game, they will get farther and there is no real losing in it – they are just doing better than the last time. So the patient would feel that they are seeing the flower growing, they are growing with the flower.”*

When asked about how useful the tool was, the designer said:

*“I think the support is done pretty well. But it’s just another tool – like anything else, it’s another tool that adds on to ease. It’s not the biggest tool to use. But it’s a good notebook to come back to. It’s a reminder that this is what this person is going through and this is what I need to focus on.”*

This comment highlighted the limitations and proper usage of information tools like GaPBIT: as a supportive channel to help game designers approach a challenging issue such as designing games for BI therapy.

#### 7.5.5 Case PD+T+G (Professional Designer + Therapist + GaPBIT)

The designer in *Case PD+T+G* was an alumnus of the game design program at DePaul University and had worked for three years designing digital games. He did not have experience designing games for health and was also not familiar with game design patterns prior to the study. During the workshop session, the designer worked with a physical therapist who rarely used video

games in her therapy sessions. Figure 32 and Figure 33 illustrate their major activities and their discussion topics across the design workshop timeline.

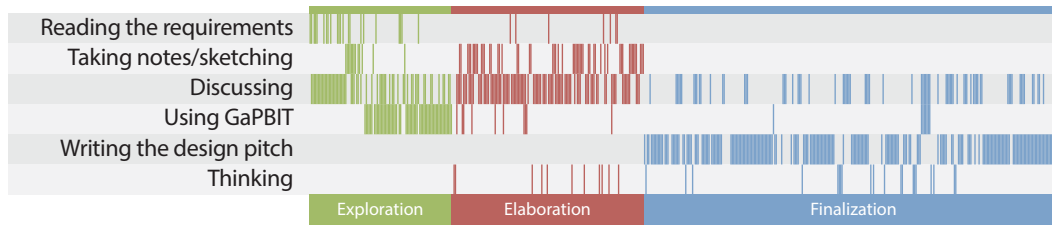


Figure 32. Major activities of participants from *Case PD+T+G*

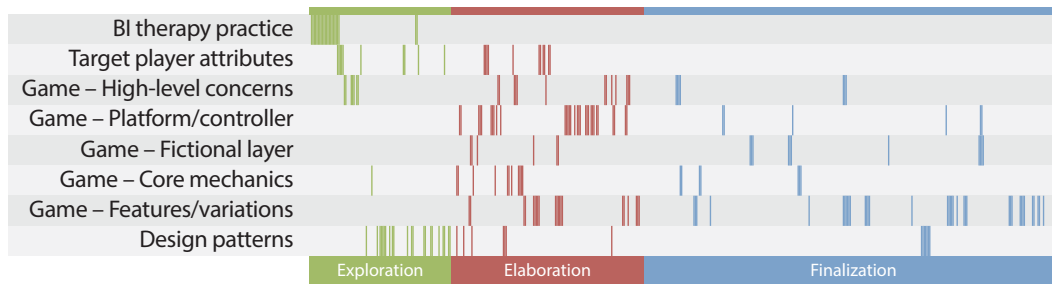


Figure 33. Discussion topics between participants from *Case PD+T+G*

The *Exploration Phase* started when both participants read the design requirements. Then the designer asked the therapist about how she usually address the therapy goals listed in the design requirement, by saying: “*When you have people who have strokes and concentration and attention issues, as well as some of those physical issues [referring to the requirements], what generally do you use in therapy?*” After the discussion about the therapist’s practice, they explored the target player’s interests and taste outlined in the requirements. They also discussed several high-level game design considerations, including the desired physical activities and the progression of visual and auditory effects/distractions.

They then used GaPBIT to explore the game design patterns. They read details about 14 patterns and saved 10 of them. During this phase, they looked at both the pattern descriptions and the example games. Sometimes the therapist suggested looking at the example games because she had seen the game been used in a therapy session. The therapist and the designer also discussed to determine which patterns to look at and save; for example:

*Therapist:* Maybe look at the Endurance goal – *Focus and Distraction?*

Since we'll need to have her walk and stand up for a prolonged period of time.

*Designer:* Okay. [*Both read the pattern description.*] Yeah. That seems to be important especially the last part [*pointing to the solution description “so that they are distracted from the fact that they are standing and/or moving”*]. And that can be integrated within the progression of the visual and sound as well. [*Saved the pattern.*]

*Therapist:* Right. Yeah. Because the more stimuli they were given, the more fatigue they will get.

After looking at the *Familiar Theme* and *Enabling Theme* patterns, they came up with a cycling game idea, indicating the end of the Exploration Phase.

In the beginning of the *Elaboration Phase*, the designer suggested reviewing the saved design patterns on GaPBIT: “*Let’s think about how we would pair some of the stuff.*” They then went through their saved patterns and discussed ideas of how to integrate each pattern in their game (see section 7.4.3). The game’s controller (i.e. a modified Wii controller with a supporting stand that resembles a bicycle handle) was determined when they were considering *Moving Different Body Parts*. The therapist also suggested several other adjustable

features when they were considering *Adjustable Speed*. The designer took extensive notes during the exploration and elaboration phases; see Figure 34 for the designer's sketch about the game's controller.

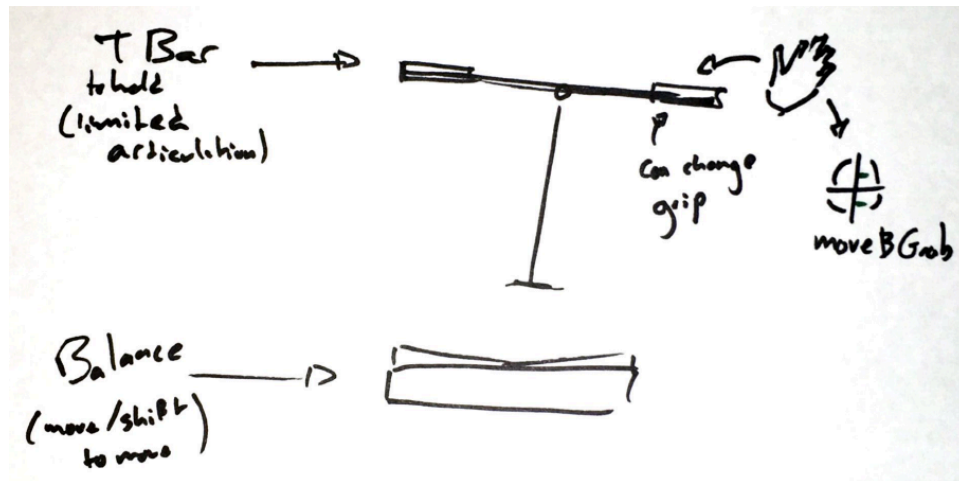


Figure 34. Designer's sketch of the game's controller from *Case PD+T+G*

The *Finalization Phase* started when the designer began to type out the design pitch. In addition to writing and editing the pitch, the participants also discussed to finalize the game's name, determine details about adjustable features, and ideate some additional game features (e.g. music as a reward of cycling faster). Notably, they used GaPBIT to check all the patterns they saved to make sure all were covered in the design pitch.

#### 7.5.6 Case SD+T+G (Student Designer + Therapist + GaPBIT)

The student designer in *Case SD+T+G* was a junior-year undergraduate student in the game design program at DePaul University. He was not familiar with game design patterns prior to the study. During the game design session, he worked with an occupational therapist who had used video games in therapy. Figure 35 and Figure 36 illustrate their design workshop timeline.

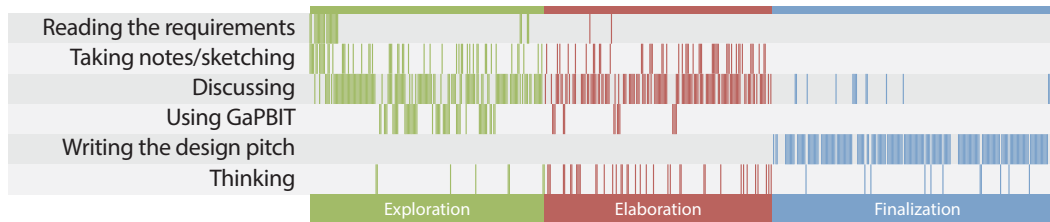


Figure 35. Major activities of participants from *Case SD+T+G*

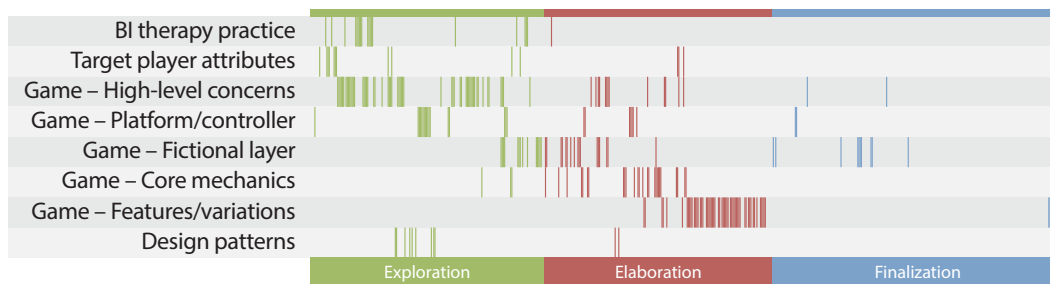


Figure 36. Discussion topics between participants from *Case SD+T+G*

At the beginning of the *Exploration Phase*, both participants read the design requirements document and the designer took notes about the target player and therapy goals. Then the designer asked about the therapist’s typical practice if he was working with a patient like the target player. The therapist brought up several high-level issues about game use in BI therapy very early in the exploration phase: *“On the Wii, [if patients did not perform well,] they say like ‘You are unbalanced.’ A lot of my patients are just like ‘Oh man.’ So the feedback is huge. And a lot of them are just way too hard. And you can’t customize them. It’s the biggest thing. We need to keep it simple, and also being able to customize without taking too much time – because in the world in rehab, time is the biggest issue.”*

After discussing these issues, they used GaPBIT to further explore the high-level considerations that the therapist brought up. They browsed, discussed,

and saved 11 game design patterns in GaPBIT. During this process, they were mostly focused on pattern descriptions and related patterns and did not explore the example games. The therapist then suggested using the mini-game format to support adjustable features: *“Maybe for our game, we can have two pathways: standing only and arm use only. Then the therapist can decide which one is more appropriate. If there is a set of mini-games, then we can divide them up into different games. ... It is also good for therapy because if one game is not motivating, we can skip it.”* The participants then agreed upon the platform, the main theme, and the core mechanics of the game: a Wii game that includes activities happened in national parks.

In the *Elaboration Phase*, they first used GaPBIT to explore several example games in the patterns they saved. They then discussed and settled on six mini-games within the national parks theme: (1) Log-Balancing, in which the player shifts weight to keep the avatar on a wooden log while crossing a river; (2) Apple Picking, in which the player catches falling apples from trees to collect in a basket; (3) Bird Watching, in which the player shifts weight to move binoculars looking for a certain kind of bird and holds the position to take a picture; (4) Trail Hiking, in which the player shifts weight to hike on a trail while trying to keep up with a trail guide; (5) Rafting, in which the player shifts weight to control the direction of the raft and uses the Wii Remote controller to paddle; and (6) Hang Gliding, in which the player uses the Wii Balance Board to balance while gliding down from a mountain. They discussed each mini-game to include different difficulty modes and other adjustable features. During this process, they revisited the design patterns they saved in GaPBIT to get clarifications and inspiration; they also extensively explored the example games associated to their saved patterns for ideation of game mechanics. The designer took extensive notes to record the ideas emerged during the discussion (see Figure 37). They then agreed



on a name of the game at the end of the elaboration phase. During the *Finalization Phase*, the participants were mostly focused on typing and editing the game design pitch. They occasionally discussed to clarify or confirm the ideas they previously generated.

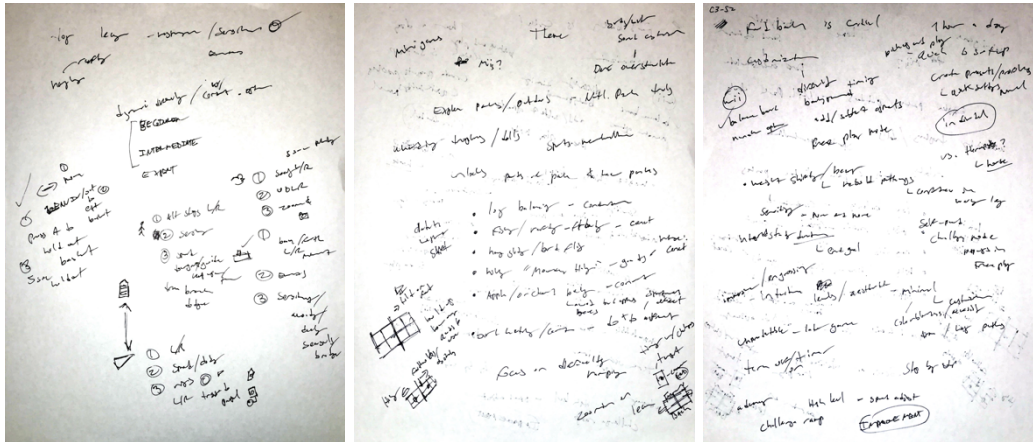


Figure 37. Notes taken by the designer in *Case SD+T+G*

## 7.6 Conclusions and Discussion

Through examining the user-centered design and evaluation of GaPBIT, I explored how an information tool incorporating game design patterns can support the creation of games for BI therapy and facilitate collaboration among designers and subject matter experts during the serious game design process. Recall that the experimental design of this evaluation study is guided by three hypotheses: (1) GaPBIT facilitates designer-therapist collaboration; (2) GaPBIT helps create unanimously better game concepts; and (3) GaPBIT better supports novice designers. While the sample size of the study was too small to quantitatively resolve those hypotheses, results from qualitative analysis provided insights to reinforce the first and the third hypotheses. During the game design workshop sessions, GaPBIT supported exploration of game design ideas and promoted an

efficient discussion between game designers and therapists. GaPBIT also effectively streamlined the design process for the novice designers to help them explore and incorporate the needs in BI therapy. Compared to professional designers, use of GaPBIT helped the novice designers achieve a considerably higher evaluation score (see section 7.3).

However, the second hypothesis was not supported in the study. Especially, using only GaPBIT (*Condition DG*) led to controversial designs that were perceived differently by designers and therapists. I especially acknowledge that designing games for health (including games for BI therapy) is a challenging task that requires expertise from different fields and involves much negotiation and compromise. As such, information tools like GaPBIT should only be considered as a supportive channel and could never substitute collaboration with subject matter experts. In the support of this argument, the highest rated games were created in *Condition DTG*, in which the collaboration between designer and therapist was mediated with GaPBIT.

It is worth noting that the results from this evaluation study supported the previous finding that games-for-health designers tend to explore both the problem and the solution spaces somewhat equally (see Chapter 4). Particularly, participants spent much of the Exploration phase to examine the current BI therapy practice and the target player's attributes. Further, the participants' approach echoed with Schön's concept of "reflection-in-action" of professional practitioners in general [168]; i.e., designers constantly engaged in critical, reflective thinking to adjust and refine their design concepts in an unfolding situation. Even with the limited time provided in the design workshops, participants still performed mini-iterations through the three design phases. Reflective thinking and adjustment manifested as a major activity in the

Exploration and Elaboration phases; and in the Finalization phase, participants still refined their design when new information and/or clarification emerged.

There are several limitations in this evaluation study that could be addressed in future work. For example, the design workshops, while realistic, were based on lab settings and did not reflect the rich considerations designers take into account in real-world game design situations. In particular, the nature of the lab setup may have influenced how participants worked in the design workshops. Especially, participants were asked to sit in front of a computer desk; this setup may have discouraged designers to stand up and conduct physical prototype when ideating the game. Further, this evaluation study is based on ethnographic/qualitative methods. While this approach afforded a detailed and rich exploration (through video coding of design workshops), the small sample did not allow a quantitative analysis to statistically examine the hypotheses guided the experimental design. Additionally, the experimental design also did not include a comparable support (e.g. book or website that provides information about BI therapy game design) in the non-GaPBIT condition to examine the effects of the pattern structure. Potential future work to address these issues are discussed in section 8.3.

## **CHAPTER 8. CONCLUSIONS**

In this dissertation, I set out to investigate conceptual and information tools to support design of therapy-centered games for brain injury rehabilitation. Following a user-centered approach, I explored the ideation, creation, and evaluation of BI therapy game design patterns and a game design tool, GaPBIT that leverages design patterns to support designers who focus on brain injury therapy games. As many types of serious games, creating games for brain injury therapy is a complicated and challenging issue that requires expertise from both designers and subject matter experts (therapists in this case). Because of this difference of expertise, however, these two groups of experts typically have differing mindsets and somewhat conflicting interests in creating games. The patterns and the game design tool discussed in this dissertation aimed to address this conflict and provide a channel to facilitate the collaboration among game designers and therapists in the design process of brain injury therapy games. In this chapter, I first summarize the four phases of research involved in this project. I then discuss the contributions and potential impacts of this study. Finally, I outline implications of this research to future work.

### **8.1 The Four Phases of Research**

The four phases of research in this project followed a user-centered approach that respectively focused on: (1) understanding the current practice and needs of designers of games for health; (2) establishing game design patterns from therapists' account of game use and initial evaluation of the patterns with game

designers; (3) user-centered design of a design tool prototype; and (4) semi-experimental evaluation of the design tool prototype that involved both game designers and therapists.

In *Phase One*, I interviewed 11 professional game designers focused on games for health to explore how they perceived and approached their work. Through this study, I aimed to explore the context and requirements for the BI therapy game design patterns and design tools. Findings revealed how the participants considered “success” and the challenges of designing games for health; I also identified various methods and tools used in their practice. Additionally, I found that the interviewees were very user-centric and tended to focus almost equally on the problem and the solution spaces when approaching game design. The designers’ user-centered efforts, however, did not always help with many challenges they met in their work, especially when consolidating interests with the subject matter experts. These insights motivated and guided the rest of this dissertation research.

In *Phase Two*, I identified 25 game design patterns through analyzing data we (Dr. Cynthia Putnam and I) gathered about therapists’ account of commercial games use in BI therapy. These game design patterns were divided into two groups: (1) *efficacy-centered* patterns that focus on enforcing therapeutic efficacy of the games and (2) *experience-centered* patterns that focus on fostering in-game experience of patients who have had a BI. I then collected initial feedback about the patterns from professional game designers and iterated the patterns based on user comments. These patterns captured qualitative information about the most “successful” games for BI rehabilitation in a structure that can facilitate sharing and expanding this body of design knowledge. While not being a comprehensive pattern language for BI therapy-centered game design, this pattern library captured the most prominent aspects of BI therapy game design and was able to

serve as a common language for designing and communicating about BI therapy games.

In *Phase Three*, I followed a user-centered approach and designed, developed, and evaluated a game design tool prototype, GaPBIT (**Game Design Patterns for Brain Injury Therapy**) that leverages the BI therapy game design patterns to support the creation of games for BI therapy and facilitate collaboration among designers and therapists during the design process. The initial GaPBIT interface was designed based on the content and structure of the design patterns. I then iterated the GaPBIT interface through usability studies with professional game designers. The current version of GaPBIT supports users browse through the inter-connected game design pattern library and allows users to save patterns in their personalized library to be used in a particular project. During usability studies, many participants expressed excitement about the tool concept.

In *Phase Four*, I examined the user experience and efficacy of the GaPBIT prototype in quasi-experimental design workshops that involved both game designers and therapists. Game designers were asked to ideate games in design workshops for a scenario-based problem focused on BI rehabilitation under three conditions: (1) interacting with a therapist, (2) using the game design tool, and (3) interacting with a therapist while using the tool. Three professional game designers and three therapists then evaluated the game design ideas generated in the workshops. During the workshops, GaPBIT supported exploration of game design ideas and effectively facilitated discussion among designers and therapists. The results also indicated that GaPBIT was especially beneficial for novice game designers. Interestingly, using only GaPBIT led to controversial designs that were praised by designer evaluators but criticized by

therapist evaluators. The highest rated games were created when GaPBIT mediated the collaboration between designer and therapist during the workshops.

## **8.2 Contributions**

The intellectual merit of this project lies in both the research outcomes and the approach. First, I investigated the BI therapy game design patterns that serve as a common language to promote communication and mutual understanding among game designers and therapists who focus on BI. Second, I explored a data-driven approach in creating the game design patterns and I focused on empirical methods in evaluating the patterns and the corresponding game design tool. In other words, the BI therapy game design patterns were generated basing on data gathered in previous work through interviews, observations, and diary studies about game therapy sessions; in addition, the patterns and the GaPBIT design tool were evaluated in qualitative studies and quasi-experiments involving both game designers and therapists. This empirical and experimental approach resulted in a novel research methodology for domains in which balancing the role of designers and other stakeholders is particularly important, such as the domain of game design for BI therapy.

This project also provides a number of broader impacts. First, this work would be able to significantly promote game design for BI rehabilitation. Providing game designers and therapists with easier access to the information about requirements in rehabilitation games will greatly encourage the design work towards this direction. This will help generate a more diverse set of rehabilitation games designed for a wider population of BI patients and thus further enrich and promote the use of games in BI therapies. Further, the game design patterns and the GaPBIT prototype could be used as an education tool to support teaching and learning of serious game design and development in higher education programs

and/or in industry training programs for therapists and game designers to establish a better mutual understanding.

Besides these projected positive outcomes for game designers, therapists, and people who have had a BI, this project also has the potential to benefit game use and creation beyond BI rehabilitation. People who have had a BI represent a diverse group with a wide range of therapeutic needs and abilities; many can generalize to other populations (e.g. elderly populations or people who undergo a physical rehabilitation because of motion disabilities). As such, some design patterns identified in this dissertation could potentially be used in serious games addressing other health conditions (e.g., cerebral palsy, Alzheimer's disease) that require therapy of the physical and cognitive goals similar to BI rehabilitation. The format of the BI therapy game design patterns and the interaction schema of the GaPBIT prototype could also generalize to games that address other types of serious goals. In other words, findings and exemplars set in this project can inform other areas of serious games.

### **8.3 Future Research Directions**

This research has several limitations that could lead to interesting future work. First, the GaPBIT prototype could be further improved. Participants mentioned they would like to comment and share design patterns; community features would be useful additions. Moreover, providing a search function, supporting project-based organization of patterns, and facilitating exploration of example games are potential improvements to explore. Second, while the small sample size of the design workshop sessions afforded a detailed and rich exploration, it did not allow a quantitative analysis to statistically examine the hypotheses guided the experimental design. Conducting a larger-scale study would be able to address this limitation. Third, while realistic the design



workshops discussed in Chapter 7 did not duplicate real-world game design situations that involve more complex issues, such as funding and interests of other stakeholders. Further, this study focused solely on the creation of initial game design ideas, rather than the evolution of fully developed games; the latter requires much more effort in playtesting and iteration. Research investigating how information and communication technologies could support serious game designers in real-world situations would be an interesting and important future direction. I plan to continue collaborating with game designers and subject matter experts to research in this area.

Considering the various challenges designers meet when creating games for BI therapy, there are many topics that remain outside the scope of this dissertation but would make important future research directions. The game design patterns and the GaPBIT tool prototype could effectively support ideation and collaboration in serious game design. However, designers still do not have sufficient support to document game design ideas in a way that facilitate communication with other stakeholders. Further, as identified in Chapter 4, designers of games for health have adapted common games user research (GUR) methods to fit in their unique context of serious game design. They also discussed limitations of the commonly used playtesting method in establishing the game's efficacy and addressing stakeholders' stereotypical assumptions about games. As a result, research that explores adaptation of traditional GUR methods in serious game design would be valuable for this group of designers. In sum, investigating how to further scaffold the serious game design process using conceptual and information tools is an important future area.

Through a "practitioner-centered" process, this work also provides an exemplar of investigating technologies that directly address the information needs of professional practitioners. While information and communication tools have

transformed how people work, most current tools have focused on work automation and increased productivity in general work places. In other words, specialized practitioners have unique needs associated with their particular domain that have not been adequately addressed in current technology. This work directly targeted on the information needs of games-for-health designers and demonstrated a research methodology for eliciting and addressing the practitioners' needs that is generalizable to related areas (i.e. domains in which balancing the role of various stakeholders is particularly important). I encourage more researchers in Human-Computer Interaction to adopt this perspective to explore technologies tailored to address the special information needs of professional practitioners in different areas.

## APPENDIX A. EFFICACY-CENTERED GAME DESIGN PATTERNS

Efficacy-centered game design patterns focused on game design considerations when addressing therapy goals in BI rehabilitation. They are grouped into four categories based on the game design aspects they address; categories included (1) patterns related to body movements and/or the physical mechanics of the game, (2) patterns addressing issues about game rules, (3) patterns concerning perception issues, and (4) patterns concerning socialization issues. Each pattern was associated with one or more therapy goals denoting the aspects of BI therapy the pattern was intended to address. Figure 38 provides an over view of the efficacy-centered patterns and illustrates their interrelationship.

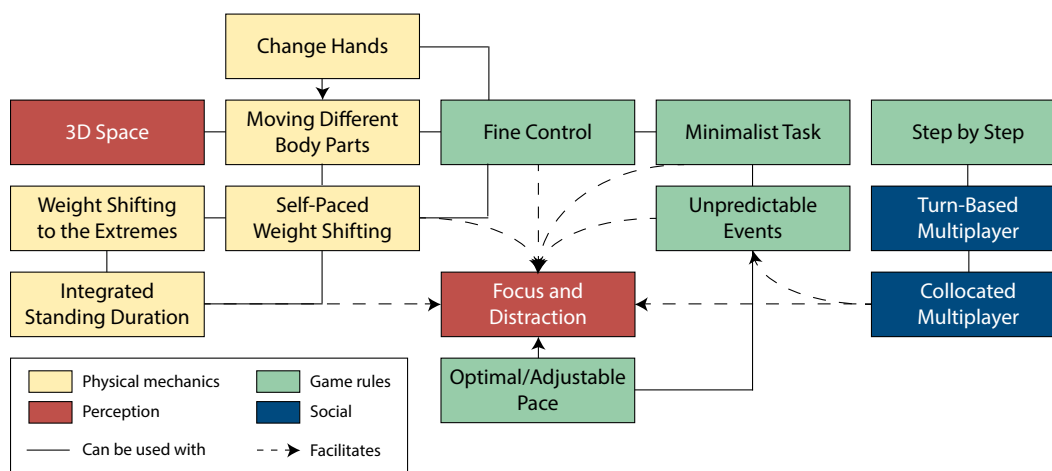


Figure 38. Interrelationship among efficacy-centered patterns

## A.1 Physical Mechanics Patterns

Physical mechanics patterns propose game design aspects about body movements in motion-based games. They mostly address physical goals in BI therapy.

### A.1.1 Change Hands

**Target Therapy Goal(s):** Bilateral hand use

**Definition:** Involving movements of both sides of the body can help encourage bilateral hand use for patients with a brain injury.

**Problem:** Patients with a brain injury may have a dominant side they prefer to use. Reestablishing the functionality of the non-dominant side can be a therapy goal of brain injury rehabilitation. A game that only requires movements of one side of the body may discourage the player to use their non-dominant side.

**Solution:** Involve movements of both sides of the body in the game. Include mechanics to encourage change of hands, arms, and/or legs so the players can work on their non-dominant side.

**Example Game(s):**

- *Kinect Sports - Boxing:* Players punch in the air to attack the opponent (either another player or a computer opponent) or hold both arms in front of face to defend. In order to effectively attack and defend, player needs to use both arms. (Game control: Kinect Sensor)
- *Kinect Sports - Table Tennis Paddle Panic:* Player hits the continuously incoming Ping-Pong balls by swinging arms as if they were holding paddles in both hands. The balls are served to different directions. The

speed and angle of the incoming balls encourage the player to use both hands to hit the balls. (Game control: Kinect Sensor)

- *Kinect Adventures - Rally Ball*: Players use limbs and head to hit virtual rally balls towards the boxes and targets located at the end of a virtual hallway; with each target dismantled, additional balls are projected back to be hit. The players are encouraged to use both arms and/or both legs in order to effectively hit the balls. (Game control: Kinect Sensor)
- *Body Brain Connection - Traffic Control*: Player holds out both arms as bridges to guide multiple cars and trucks moving on platforms to the destinations designated by the vehicle's color. In order to play the game, the player has to hold out and move both arms. The game also provides a cognitive challenge for players to find solutions guiding multiple vehicles to their corresponding destinations, so the player sometimes needs to be aware of future events and adjust the positions of both arms accordingly. (Game control: Kinect Sensor)

**Related Patterns:**

- Can be used with *Fine Control* to practice control over both sides of the body.
- Facilitates *Moving Different Body Parts* to help address the insights into deficits goal.

A.1.2 Integrated Standing Duration

**Target Therapy Goal(s):** Standing

**Definition:** Standing duration can be integrated into the game's challenge to encourage standing for patients with different standing abilities.

**Problem:** Therapists may use games to motivate patients to stand. However, games involve fixed standing durations (e.g. a time limit) may not be suitable for a wider range of patients who have different standing abilities. Patients with a shorter standing endurance will not be able to play the game; and for those with a longer standing endurance, the game will not be challenging enough to improve the standing ability.

**Solution:** Allow the player to determine how much time they will stand by just playing the game. Eliminate time limits. Instead, provide alternative limits (e.g. number of life, increased challenge level) that integrate standing into the challenge of the game so that the players may always meet their standing duration limits.

**Example Game(s):**

- *Wii Fit - Table Tilt:* Players shift weight on a balance board in all directions (front-and-back and side-to-side) to tilt a table and guide marbles through holes. While each level has a time limit, the total standing time is integrated: higher level players can clear the first levels fast and focus more on the more challenging levels (unused time will be carried over to later levels); lower level players can play the first few levels and get a good practice on standing. (Game control: Wii Balance Board)
- *Kinect Sports - Table Tennis:* Player stands and swings one arm to play table tennis with another player or a computer opponent. Standing is integrated in that there is no time limit on the game - players win or lose by earning a certain amount of points. (Game control: Kinect Sensor)
- *Wii Fit - Balance Bubble:* Player's avatar stands in a bubble that runs along a stream. Players shift weight front and back to control the speed of the

bubble and shift weight from side to side to steer the bubble; the goal is to reach the finish line while avoiding the riverbank and other obstacles (e.g. a flying bee). Whenever the bubble hits the bank or an obstacle, the game ends - so the standing and weight-shifting requirements are integrated in the challenge of the game. (Game control: Wii Balance Board)

**Related Patterns:**

- Usually used with *Self-Paced Weight Shifting* to help players concentrate on weight shifting activities (e.g. without the distractions of time limit).
- Sometimes used with *Weight Shifting to the Extremes* to create a balanced level of challenge for standing, weight shifting and balance.
- *Integrated Standing Duration* usually creates a good balance between challenge and skill (encouraging engagement) and thus facilitates *Focus and Distraction*.

A.1.3 Moving Different Body Parts

**Target Therapy Goal(s):** Insight into deficits

**Definition:** Involving movement of different body parts or different muscles can promote awareness of physical deficits for patients with a brain injury.

**Problem:** An awareness of the exact area of physical deficits is important for patients with a brain injury to be motivated and focused on certain aspects of rehabilitation. But patients with a brain injury may not have this awareness due to cognitive impairments.

**Solution:** Give the player opportunity to control game objects by using different muscles or different parts of the body and provide clear performance feedback so that they can see the exact area of their deficits.

**Example Game(s):**

- *Wii Fit - Table Tilt:* Players shift weight on a balance board in all directions (front-and-back and side-to-side) to tilt a table and guide marbles through holes. The game requires control and frequent change of weight-shifting directions. It also provides direct visual and gameplay feedback associated with their weight-shifting actions involving multiple body parts. This is important for patients to gain insights into their physical deficits such as balancing and neglect on one side of the body. (Game control: Wii Balance Board)
- *Wii Fit - Soccer Heading:* Players shift weight from side to side to head soccer balls that are kicked in, while avoiding hitting foils. The players are required to weight-shift fast from left to right - this requirement helps patients to notice if they have a weaker side and to establish insights into their perception and reaction deficits. (Game control: Wii Balance Board)
- *Kinect Adventures - 20,000 Leaks:* The player's avatar is in a glass cube underwater. The player positions limbs and head to plug cracks as crabs, fish, and sharks hit the cube; if multiple cracks appear, the player has to plug all of them at the same time. The requirement of moving all limbs helps players to establish a comprehensive understanding about the movement of their limbs and gain deep insights if they have a physical deficit. (Game control: Kinect Sensor)



- *Kinect Adventures - Rally Ball*: Players use limbs and head to hit virtual rally balls towards the boxes and targets located at the end of a virtual hallway; with each target dismantled, additional balls are projected back to be hit. The requirement of moving all parts of the body helps players to establish a comprehensive understanding about the movement of their body and gain insights if they have a physical deficit. (Game control: Kinect Sensor)

**Related Patterns:**

- Can be facilitated by using *Change Hands*.
- Can be used with *Fine Control* to practice control over different parts of the body.
- Usually used in *Three-Dimensional Space* to include movements in different dimensions.
- When focusing on weight shifting, it is usually used with *Self-Paced Weight Shifting* to help patients focused on the deficit in a low-pressure environment.

A.1.4 Self-Paced Weight Shifting

**Target Therapy Goal(s):** Balancing; Weight shifting

**Definition:** Allowing players to determine the timing of weight shifting can help the patients with a brain injury focus on the weight shifting mechanics and limit unnecessary challenges (from limited processing time).

**Problem:** Practicing dynamic balance often includes activities involving weight shifting (side-to-side and/or front-to-back). Patients who are rehabilitating

on dynamic balance and weight shifting abilities often have coordination issues that affect their reaction time to events.

**Solution:** Allow players to adjust the timing of weight shifting according to their own coordination and balancing abilities. Do not impose fix-paced actions.

**Example Game(s):**

- *Wii Fit - Table Tilt:* Players shift weight on a balance board in all directions (front-and-back and side-to-side) to tilt a table and guide marbles through holes. There is a timer for each level (which is usually perceived by therapists as a negative element). But there are no fix-paced events and players can perform weight shifting at their own pace. (Game control: Wii Balance Board)
- *Wii Fit - Penguin Slide:* Players shift weight from side to side to tilt an iceberg and let a penguin that slides on it catch fish jumping out from the water. While the timing in which the fish jump out follows a pattern, players do not have to react to that pace to catch them. In other words, players can perform weight shifting at their own pace. (Game control: Wii Balance Board)
- *Kinect Sports - Soccer Target Kick:* Players kick virtual soccer balls to hit the targets that are protected by a goalie. Players do not have to react to any events and can kick at their own pace. Note that kicking involves weight shifting, especially when alternating legs. (Game control: Kinect Sensor)

**Anti Example Game(s):**

- *Wii Fit - Soccer Heading*: Players shift weight from side to side to head soccer balls that are kicked in, while avoiding hitting foils. Players shift weight from side to side to head soccer balls that are kicked in, while avoiding hitting foils. The pace of the weight shifting has to follow that of the incoming balls and is usually too fast for patients who have had a brain injury. (Game control: Wii Balance Board)

**Related Patterns:**

- Can be used with *Weight Shifting to the Extremes* to further support practice of weight shifting.
- Can be used with *Moving Different Body Parts* to support weight shifting in all directions and facilitate insights into deficits in weight shifting.
- Can be used with *Integrated Standing Duration* to help practice standing.
- With *Self-Paced Weight Shifting*, patients will have more time thinking, feeling, and/or reflecting upon their movements; so it can be easily combined with *Fine Control* to practice weight-shifting precisions.
- This pattern facilitates a sense of autonomy and thus can encourage player motivation; so it can be used to promote *Focus and Distraction*.

A.1.5 Weight Shifting to the Extremes

**Target Therapy Goal(s):** Weight shifting

**Definition:** Encouraging movement to the most feasible extend when weight shifting can support physical training for patients with a brain injury and help then be aware of their physical competences and limitations.

**Problem:** Patients can sometimes be afraid to shift their weights to the extremes even after they have regained balancing abilities. That is, they do not have the confidence performing certain activities even after they have regained the physical competence. This can affect patients' balance and gait and restrict their daily functioning.

**Solution:** Encourage patients to shift their weight side-to-side to the extremes (to the most feasible extent) to support physical training and help patients see their physical competences and limitations. Extra support is usually needed to protect patients from falling.

**Example Game(s):**

- *Wii Fit - Soccer Heading:* Players shift weight from side to side to head soccer balls that are kicked in, while avoiding hitting foils. The soccer balls are often kicked in to the sides, so it encourages players to shift weight to the extremes in order to hit them effectively. (Game control: Wii Balance Board)
- *Wii Fit - Penguin Slide:* Players shift weight from side to side to tilt an iceberg and let a penguin that slides on it catch fish jumping out from the water. While players can shift weight at their own pace and degree, the game encourages players to shift weight to the extremes by awarding more points - the red fish (with bonus scores) often appears at the edge of the iceberg. (Game control: Wii Balance Board)

**Related Patterns:**

- Can be used with *Self-Paced Weight Shifting* to help players be more focused and more comfortable to shift their weight to the extremes.

- Can be used with *Integrated Standing Duration* to also practice standing.

## A.2 Game Rules Patterns

Game rules patterns address game design issues about the rules. They are mostly focused on the connection between the physical goals and the cognitive aspects in BI therapy.

### A.2.1 Fine Control

**Target Therapy Goal(s):** Balancing; Weight shifting

**Definition:** Focusing on precision of action and promoting refined control on physical activities in game tasks can help patients with a brain injury practice certain physical abilities.

**Problem:** Given for granted, a typical person may find certain actions (e.g. weight shifting) easy to perform. However, patients with a brain injury would have to exert a considerable amount of physical and cognitive efforts to practice these abilities. A conscious awareness of certain body movements facilitated through refined control is crucial for rehabilitating on these actions. But patients with a brain injury may lack this kind of awareness and control. Practicing fine control is thus important for improving related physical abilities.

**Solution:** Involve mechanics to encourage fine control on physical activities that focus on precision of action and awareness of movements. For example, a refined control on the direction and degree of weight shifting is important for patients to improve weight-shifting precision and thus improve balance and gait.

**Example Game(s):**

- *Wii Fit - Table Tilt*: Players shift weight on a balance board in all directions (front-and-back and side-to-side) to tilt a table and guide marbles through holes. Players need to be aware of the degree and direction of their weight-shifting actions and provide fine control in order to move the marbles towards the holes while keeping all marbles from falling off the table. (Game control: Wii Balance Board)
- *Wii Fit - Penguin Slide*: Players shift weight from side to side to tilt an iceberg and let a penguin that slides on it catch fish jumping out from the water. To effectively catch the fish, players need to be aware of and control the degree and the timing of weight-shifting actions. (Game control: Wii Balance Board)
- *Kinect Sports - Soccer Target Kick*: Players kick virtual soccer balls to hit the targets that are protected by a goalie. Players are encouraged to control the direction of kicking in order to trick the goalie and hit the target. In addition, the players need to keep their balance to facilitate the kicking. (Game control: Kinect Sensor)

**Related Patterns:**

- Usually used with *Change Hands* to practice control over a non-dominant side of the body.
- Usually used with *Moving Different Body Parts* to practice control over different parts of the body and gain insights into deficits.
- When targeting weight shifting, *Fine Control* is usually used with *Self-Paced Weight Shifting*, in which patients will have more time thinking and feeling upon their movements.

- Usually used with *Minimalist Task* to focus on practice of a particular action.
- *Fine Control* encourages players to be extremely focused on the activity, and thus promotes *Focus and Distraction*.

### A.2.2 Minimalist Task

**Target Therapy Goal(s):** Attention and concentration

**Definition:** Involving minimalist but interesting player choices in the game task can promote attention and concentration for patients with a brain injury.

**Problem:** Patients sometimes have a limited attention and concentration span that needs to be addressed in therapy. A game that involves complicated tasks (e.g. tasks that involve multiple steps) will be too challenging for them to understand and learn. However, if a game is too simple and dry, player can easily lose interest.

**Solution:** Provide simple tasks that involve a minimal number of possible player actions or action steps; but on the other hand pose an appropriate level of challenge on the control of the attributes of the actions (e.g. timing or intensity) to promote concentration.

**Example Game(s):**

- *Wii Fit - Table Tilt*: Players shift weight on a balance board in all directions (front-and-back and side-to-side) to tilt a table and guide marbles through holes. While the movement is simple (i.e. weight shifting), players need to carefully control the direction and degree of

weight shifting in order to move the marbles towards the holes and prevent them from falling off the table. (Game control: Wii Balance Board)

- *Wii Fit - Soccer Heading*: Players shift weight from side to side to head soccer balls that are kicked in, while avoiding hitting foils. The movement is simple, but controlling when and to which direction to shift the weight (in reaction to the incoming balls) poses an interesting challenge. (Game control: Wii Balance Board)
- *Wii Sports Resort - Swordplay-Speed Slice*: Players swing the Wii remote in the direction specified on an object when it appears to cut the object. Identifying and reacting to the specified direction pose interesting challenges to a simple task (arm swing). (Game control: Wii Remote Controller)

**Related Patterns:**

- Can be used with *Fine Control* to focus on the precision of a movement.
- Usually used with *Unpredictable Events* to impose challenge and address hand-eye coordination goals.
- *Minimalist Task* strengthens attention and concentration and thus promotes *Focus and Distraction*.

A.2.3 Optimal/Adjustable Pace

**Target Therapy Goal(s):** Processing speed

**Definition:** When focusing on improving processing speed, allowing players to adjust the pace of game events can accommodate different patient abilities.



**Problem:** When working on processing speed, a relatively fast-paced game is usually desired. But setting an appropriate game speed can be tricky since all patients have different abilities and impairments. While a game that is too fast can be intimidating and not playable by many patients, a game that is too slow may sometimes not be able to pose enough challenge for high-level patients and thus can be ineffective at addressing the desired therapy goals.

**Solution:** Allowing therapists or patients to adjust the pace (or automatically adjust the pace) of the game. While many commercial games do not have the desired adjustable features, therapists identified that adding such feature to games that were effective at addressing Processing Speed can potentially benefit a wider range of patients.

**Anti Example Game(s):**

- *Kinect Sports - Table Tennis Paddle Panic:* Player hits the continuously incoming Ping-Pong balls by swinging arms as if they were holding paddles in both hands. It is an effective game at addressing Processing Speed for high-level patients. But the speed of the incoming balls is too fast for many patients and is not adjustable. (Game control: Kinect Sensor)
- *Wii Fit - Soccer Heading:* Players shift weight from side to side to head soccer balls that are kicked in, while avoiding hitting foils. The pace of the weight shifting has to follow that of the incoming balls and is not adjustable. The default pace is too fast for many patients who have had a brain injury. (Game control: Wii Balance Board)

**Related Patterns:**

- *Self-Paced Weight Shifting* mainly concerns the pace of player actions, while *Optimal/Adjustable Pace* concerns the pace of events happening in the game.
- Usually used with *Unpredictable Events* to make sure the events happen in a pace that matches player abilities.
- *Optimal/Adjustable Pace* focuses on balancing the challenge of the game and player skill, and thus facilitates player engagement and can create *Focus and Distraction*.

#### A.2.4 Unpredictable Events

**Target Therapy Goal(s):** Hand-eye coordination

**Definition:** Making game events somewhat unpredictable can promote perception, reaction, and hand-eye coordination abilities for patients with a brain injury.

**Problem:** Practicing hand-eye coordination abilities usually involves perception and reaction to events. A game with periodical or predictable events can limit its effectiveness on rehabilitation of hand-eye coordination abilities.

**Solution:** Make events appear in a somewhat unpredictable manner to introduce uncertainty in the game. A fairly fast pace is often desired but the speed needs to match patient abilities. A human opponent with a matching skill or an adjustable computer opponent can sometimes provide unpredictable events in an appropriate pace.

**Example Game(s):**

- *Wii Sports Resort - Swordplay-Speed Slice*: Players swing the Wii remote in the direction specified on an object when it appears to cut the object. The direction is randomized and the players need to react to the specified direction as fast as possible. (Game control: Wii Remote Controller)
- *Kinect Sports - Table Tennis*: Player stands and swings one arm to play table tennis with another player or a computer opponent. Players need to react to the somewhat unpredictable direction and speed of the ball and swing their arm accordingly. (Game control: Kinect Sensor)
- *Kinect Sports - Boxing*: Players punch in the air to attack the opponent (either another player or a computer opponent) or hold both arms in front of face to defend. Players need to react to the opponent's actions and to attack or defend accordingly. (Game control: Kinect Sensor)
- *Kinect Adventures - Rally Ball*: Players use limbs and head to hit virtual rally balls towards the boxes and targets located at the end of a virtual hallway; with each target dismantled, additional balls are projected back to be hit. Players need to react to the somewhat unpredictable direction and speed of the balls and coordinate their body to hit the balls. (Game control: Kinect Sensor)

**Related Patterns:**

- Usually Used with *Optimal/Adjustable Pace* to make sure the Unpredictable Events happen in a pace that matches player abilities.
- Usually used with *Minimalist Task* to target on support training of attention and concentration.
- *Unpredictable Events* can promote *Focus and Distraction*.

- Supporting real-time (i.e. not turn-based) *Collocated Multiplayer* can be a way to create Unpredictable Events.

#### A.2.5 Step by Step

**Target Therapy Goal(s):** Command following; Sequencing

**Definition:** Require sequential player actions in game tasks can promote sequencing and command following abilities for patients with a brain injury.

**Problem:** Brain injury therapy may focus on improving patients' ability to understand and follow steps. Game actions that do not include sequential elements would not be effective at addressing this goal.

**Solution:** Include several steps in actions that are required to accomplish a certain activity in the game. Emphasize on the sequential relationships among those steps.

**Example Game(s):**

- *Wii Sports - Bowling:* Players play a virtual bowling game against up to three other players or computer opponents. Players need to follow three steps to bowl: (1) push B button, (2) swing their arm, and (3) release the button at a point of the swing when they want to release the ball. Players need to understand this sequence in order to play this game. (Game control: Wii Remote Controller)
- *Minute to Win it - Bucket Head:* Players throw virtual Ping-Pong balls to a wall and catch the rebounding balls using a virtual bucket strapped on head. Players need to follow three steps to catch a ball: (1) reach arm to the side to grab a virtual ball, (2) throw the ball overhead, (3) step and/or

lean left and right to aim and catch the ball. Players need to understand this sequence in order to play this game. (Game control: Kinect Sensor)

- *Wii Sports - Golf*: Players play a virtual golf game using the Wii Remote. Players need to follow three steps to play the game: (1) adjust the swing direction by pushing the direction buttons on the Wii remote, (2) point the Wii remote to the floor mimicking holding a golf club, (3) hold the A button on the remote and swing as if playing golf. Players need to understand this sequence in order to play this game. (Game control: Wii Remote Controller)

**Related Patterns:**

- Sometimes used with *Turn-Based Multiplayer* to support both sequencing and social interaction.

### **A.3 Perception Patterns**

Perception patterns address visual, auditory, or other perception issues in creating effective BI therapy games. Like Game Rule Patterns, Perception Patterns are also focused on the connection between physical and cognitive aspects in BI therapy.

#### **A.3.1 Focus and Distraction**

**Target Therapy Goal(s):** Endurance; Standing

**Definition:** Including intriguing game elements can help distract players with a brain injury from the fact that they are performing activities physically difficult for them (e.g. standing).

**Problem:** Therapists may use games to promote patients' endurance (e.g. standing endurance). But for patients who have had a brain injury, standing and moving usually require a considerable amount of effort. A less engaging gaming experience will discourage the efforts to practice for an extended time.

**Solution:** Provide intriguing game elements and/or activities that promote concentration and encourage players to focus on the game, so that they are distracted from the fact that they are standing and/or moving.

**Example Game(s):**

- *Kinect Sports - Boxing:* Players punch in the air to attack the opponent (either another player or a computer opponent) or hold both arms in front of face to defend. Players are encouraged to watch the opponent's actions closely and react fast - this promotes concentration and focus. (Game control: Kinect Sensor)
- *Wii Fit - Table Tilt:* Players shift weight on a balance board in all directions (front-and-back and side-to-side) to tilt a table and guide marbles through holes. The game has a very clear goal and a straightforward task. It poses interesting challenge on controlling the weight-shifting actions and supports concentration and focus. (Game control: Wii Balance Board)
- *Wii Fit - Penguin Slide:* Players shift weight from side to side to tilt an iceberg and let a penguin that slides on it catch fish jumping out from the water. The theme and music of the game provides good distraction for suitable patients. Keeping the penguin on the iceberg is a straightforward task with appropriate challenge that promotes focus. (Game control: Wii Balance Board)

- *Wii Sports Resort - Swordplay-Speed Slice*: Players swing the Wii remote in the direction specified on an object when it appears to cut the object. Identifying and reacting to the specified direction pose interesting challenge and promote concentration and focus. (Game control: Wii Remote Controller)

**Related Patterns:**

- Can be facilitated using many other patterns, including *Integrated Standing Duration, Self-Paced Weight Shifting, Fine Control, Minimalist Task, Optimal/Adjustable Pace, Unpredictable Events, and Collocated Multiplayer*.

### A.3.2 Three-Dimensional Space

**Target Therapy Goal(s):** Visual-spatial abilities

**Definition:** Including easy-to-understand 3D environments can promote visual spatial abilities for patients with a brain injury.

**Problem:** Brain injuries can have an impact on patient's ability to understand spatial relationships among objects. This can further affect their navigation skills and visual memory.

**Solution:** Include a simple three-dimensional space in the game to support rehabilitation of visual spatial abilities. Involve object movement and rotation to promote understanding of spatial relationships. Make sure the complexity of the space and the movement matches the patient's abilities.

**Example Game(s):**

- *Wii Fit - Table Tilt*: Players shift weight on a balance board in all directions (front-and-back and side-to-side) to tilt a table and guide marbles through holes. The table tilts in a three-dimensional space according to the player's weight shifting directions and spins when a marble falls off the table, so it promotes and challenges on the player's visual spatial abilities. (Game control: Wii Balance Board)
- *Kinect Adventures - 20,000 Leaks*: The player's avatar is in a glass cube underwater. The player positions limbs and head to plug cracks as crabs, fish, and sharks hit the cube; if multiple cracks appear, the player has to plug all of them at the same time. In order to play the game, players need to mentally map their body to their avatar in the game and their environment to the virtual cube. In other words, they need to understand relationships among objects in the real-world space and objects in a virtual three-dimensional space to play the game. (Game control: Kinect Sensor)

**Related Patterns:**

- Can be used with *Moving Different Body Parts* to include movements in different dimensions.

**A.4 Social Patterns**

Social Patterns address social goals in BI therapy. They are mostly focused on multiplayer game design issues.

A.4.1 Collocated Multiplayer

**Target Therapy Goal(s):** Socialization



**Definition:** Collocated multiplayer games can be a 'safe' in-person socializing space for patients with a brain injury.

**Problem:** Patients who have had a brain injury need to be connected with their friends and family, their community, and the rest of the world. Some patients have difficulty socializing with other people because of self-consciousness caused by their disabilities.

**Solution:** Games can create a 'safe' socializing space. Include collocated multiplayer features to encourage in-person social interaction. Preferably, include real-life activities players are already familiar with to facilitate socialization.

**Example Game(s):**

- *Wii Sports or Kinect Sports - Bowling:* Players play a virtual bowling game against up to three other players. Bowling alleys are usually social spaces in real life. But patients with brain injury are usually not able to play a real bowling game because of a disability. A video game of bowling naturally supports collocated social interaction and attracts players who used to bowl prior to brain injury. (Game control: Wii Remote Controller or Kinect Sensor)
- *Kinect Sports - Boxing:* Players punch in the air to attack the opponent (either another player or a computer opponent) or hold both arms in front of face to defend. Two patients or a patient and his/her caregiver can play a competitive boxing game. The intense physical activity involved in the game adds flavor to collocated socialization. (Game control: Kinect Sensor)
- *Wii Sports Resort - Swordplay-Speed Slice:* Players swing the Wii remote in the direction specified on an object when it appears to cut the object.

Two players can compete in reaction speed and socialize through playing the game. The player who swings the first in the correct direction earns a point. (Game control: Wii Remote Controller)

**Related Patterns:**

- Can be used to create *Unpredictable Events* to facilitate *Focus and Distraction*.
- Can be used with *Turn-Based Multiplayer* to support in-person socialization and turn taking.

A.4.2 Turn-Based Multiplayer

**Target Therapy Goal(s):** Turn taking

**Definition:** Turn-based multiplayer games can be socializing spaces to support practicing turn taking skills for patients with a brain injury.

**Problem:** Turn taking is an important social skill (e.g. in conversations) that is influenced by subtle cultural factors. Brain injuries can sometimes have an impact on this skill and thus affect the patient's ability to interact with other people. Games involving concurrent multiplayer activities (e.g. table tennis, boxing) were not effective at addressing this goal.

**Solution:** Include turn-based multiplayer features (preferably collocated) to promote social interaction in games and support practicing turn taking skills.

**Example Game(s):**

- *Wii Sports or Kinect Sports - Bowling*: Players play a virtual bowling game against up to three other players. In a bowling game, it is always clear as to who is playing and who is waiting. Players need to understand

that they have to wait until all other players finish their turn to play the next turn. (Game control: Wii Remote Controller or Kinect Sensor)

**Related Patterns:**

- Usually used with *Collocated Multiplayer* to further encourage in-person social interaction, especially when there is a long lag time between turns.
- Can be used with *Step by Step* to support both sequencing and social interaction.

## APPENDIX B. EXPERIENCE-CENTERED GAME DESIGN PATTERNS

Experience-centered game design patterns focus on fostering in-game experience of patients who have had a BI. They are grouped into four categories that address different game design aspects: (1) patterns aimed at presenting appropriate challenges to the player, (2) patterns concerning the learnability and the learning ramp of the game, (3) patterns focusing on creating a sense of progress through the game, and (4) patterns addressing aspects to consider when creating the game’s theme. Figure 39 provides an over view of the experience-centered patterns and illustrates their interrelationship.

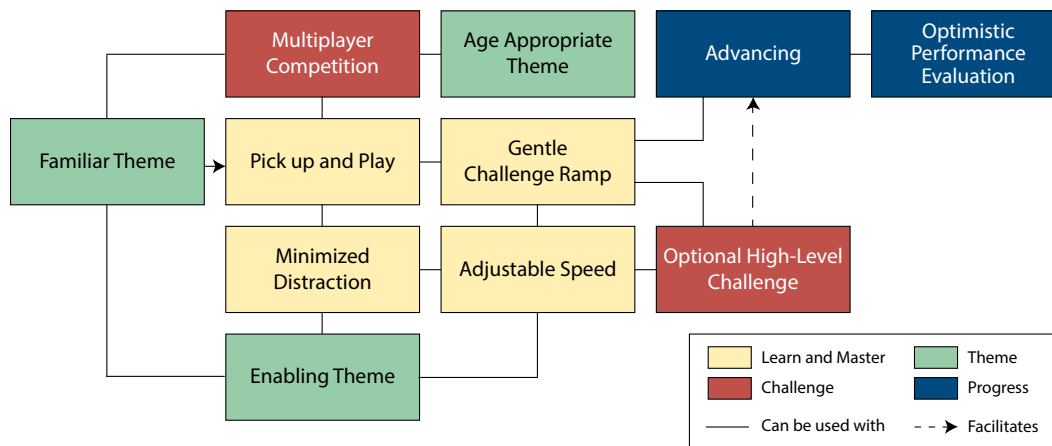


Figure 39. Interrelationship among experience-centered patterns

## B.1 Challenge Patterns

Challenge patterns aim to create appropriate challenges in the game to match the diverse abilities and skills of players who have had a BI.

### B.1.1 Multiplayer Competition

**Definition:** Multiplayer competitive play (with peer patients or caregivers) can provide an appropriate amount of challenge as a motivator for players with a brain injury.

**Problem:** Challenge can be stressful for people who have had a brain injury. However, an appropriate amount of challenge is motivating.

**Solution:** Support multiplayer to foster competition and socialization so that they can play with their peer patients who have similar level of skills or with their caregivers who can adjust the challenge level based on the patient's skill. This way, they get an appropriate amount of challenge from the other players.

#### **Example Game(s):**

- *Wii Sports or Kinect Sports - Bowling:* Players play a virtual bowling game against up to three other players. This is a popular game in the hospital that patients spontaneously play with their peer patients in spare time. (Game control: Wii Remote Controller or Kinect Sensor)
- *Kinect Sports - Boxing:* Players punch in the air to attack the opponent (either another player or a computer opponent) or hold both arms in front of face to defend. The easiest level of the computer opponent is usually still very difficult for players who have had a brain injury. But when two players play together, the challenge level can be adjusted by the performance of the other player. (Game control: Kinect Sensor)

- *Wii Sports Resort - Swordplay-Speed Slice*: Players swing the Wii remote in the direction specified on an object when it appears to cut the object. Two players can compete in reaction speed. The player who swings the first in the correct direction earns a point. The challenge level of reaction speed thus comes from the other player, who, if is also a patient, can provide a challenge level that matches the player's skill and ability. (Game control: Wii Remote Controller)

**Related Patterns:**

- Games with *Age Appropriate Theme* can be engaging to be played by patients with friends who are of the similar age, and thus are good candidates for *Multiplayer Competition*.
- *Multiplayer Competition* is usually used with games that are easier for patients to *Pick up and Play* so that new players don't have to go through a steep learning curve.
- Games with a *Familiar Theme* to a certain patient group are good candidates for *Multiplayer Competition*.

### B.1.2 Optional High-Level Challenge

**Definition:** If high-level challenges are optional, these challenges would not intimidate low-level patients with a brain injury and they can serve as a bonus to motivate high-level patients.

**Problem:** Because of the wide range of physical and cognitive effects of BIs, it is difficult to identify a “right” level of challenge to accommodate a range of patients who have had a BI.

**Solution:** Provide regular challenges throughout the play but occasionally give the player optional higher-level challenges. The high-level challenges should NOT be associated with the progress of the game; instead, they should provide appropriate incentives (e.g. bonuses) to encourage players to accomplish them.

**Example Game(s):**

- *Wii Fit - Penguin Slide:* Players shift weight from side to side to tilt an iceberg and let a penguin that slides on it catch fish jumping out from the water. Blue fish are easiest to catch but provide the lowest points, followed by green fish; those are regular challenges. Red fish (high-level challenges) appear occasionally, are very difficult to catch, and provide the highest points. Players do not have to catch the red fish to finish the game; in fact, some therapists advised the patient to ignore the red fish because they are too difficult. But for higher-level patients, the red fish are rewarding challenges. (Game control: Wii Balance Board)
- *Kinect Adventures - River Rush:* The player's avatar stands on a raft that is moving down a river. The player steps left and right and jumps to control the raft in order to collect points scattered throughout the river. There are bonus points that involve a lot of jumping and skillful steering to enter and stay in (i.e. high-level challenges); but those are all optional to the players. (Game control: Kinect Sensor)

**Anti Example Game(s):**

- *Wii Fit - Balance Bubble:* Player's avatar stands in a bubble that runs along a stream. Players shift weight front and back to control the speed of the bubble and shift weight from side to side to steer the bubble; the goal is to reach the finish line while avoiding the riverbank and other obstacles (e.g.

a flying bee). The riverbank with gentle curves represents regular challenges, while the riverbank with sharp curves and some moving obstacles represents high level challenges. Whenever the bubble hits the bank or an obstacle, the player has to start from the very beginning of the stream; in other words, the high level challenges are not optional. Many patients with brain injuries consider the high level challenges in this game as frustrating. Very few patients can reach the final line, even for the first level. (Game control: Wii Balance Board)

- *Wii Fit - Obstacle Course*: Players walk in-place and 'jump' (bend and then extend knees) to control the avatar through various obstacles. Obstacles that require walking and waiting (e.g. to step on a moving platform, or to avoid a moving ball) represents regular challenges, while obstacles that requiring 'jumping' represents high-level challenges (some patients don't have coordination to balance when knees are bent). The high-level challenges are not optional. Whenever failed to pass an obstacle, the player has to replay the level. This frustrates many patients with a brain injury. (Game control: Wii Balance Board)

**Related Patterns:**

- *Optional High-Level Challenge* requires that the high-level challenges are not associated with the progress of the game, so it promotes *Advancing*.
- Can be used with *Adjustable Speed* to accommodate wider range of patients.
- Can be used with *Gentle Challenge Ramp* to promote player engagement with the optional high-level challenges.



## B.2 Learn and Master Patterns

Learn and master patterns address game design aspects about learnability and learning ramp of the game.

### B.2.1 Adjustable Speed

**Definition:** Allowing the players to adjust the speed of the game can accommodate different patient perception and reaction abilities.

**Problem:** Depending on the type of brain injury, patients may have different levels of perception and reaction abilities. A fixed game speed may be too fast for some players but at the same time too slow for others.

**Solution:** If the game involves challenges to players' reaction speed, allow the players or the caregivers to adjust the speed of the game so that a wider range of patients can enjoy it.

#### **Anti Example Game(s):**

- *Kinect Adventures - River Rush:* The player's avatar stands on a raft that is moving down a river. The player steps left and right and jumps to control the raft in order to collect points scattered throughout the river. The raft moves too fast for many players with a brain injury to perceive and react to the changes in the environment; the player could not control the speed. (Game control: Kinect Sensor)
- *Kinect Sports - Table Tennis Paddle Panic:* Player hits the continuously incoming Ping-Pong balls by swinging arms as if they were holding paddles in both hands. The speed of the incoming balls is not adjustable and is too fast for many patients. (Game control: Kinect Sensor)

- *Wii Fit - Soccer Heading*: Players shift weight from side to side to head soccer balls that are kicked in, while avoiding hitting foils. The speed of the incoming balls is not adjustable and is too fast for many patients who have had a brain injury. (Game control: Wii Balance Board)

**Related Patterns:**

- *Adjustable Speed* allows a game with an *Enabling Theme* to be more enjoyable to patients with wider range of abilities.
- Can be used with *Minimized Distraction* to further avoid overwhelming patients.
- Can be used with *Optional High-Level Challenge* to adjust the optimized level of challenge for a wider range of players.
- Can be used with *Gentle Challenge Ramp* to adjust the starting challenge level for a wider range of players.

### B.2.2 Gentle Challenge Ramp

**Definition:** To promote a feeling of being in control for players with a brain injury, the challenge level of a game can be increased at a slower rate and new challenges or mechanics can be introduced at a slower rate.

**Problem:** It usually takes longer for a patient who had a brain injury to get ready to meet more difficult challenges even if they have learned the basics of a game. It takes longer for them to master the basics and come up with variations to solve new challenges.

**Solution:** Increase the challenge level or introduce new challenges or mechanics at a slower rate so that the player will be able to practice and master the required skills.

**Example Game(s):**

- *Kinect Adventures - River Rush:* The player's avatar stands on a raft that is moving down a river. The player steps left and right and jumps to control the raft in order to collect points scattered throughout the river. When player move to a new level, the challenge level stays almost the same. The new river provides a sense of novelty; the new secrete areas provide new but optional challenges. (Game control: Kinect Sensor)

**Anti Example Game(s):**

- *Wii Fit - Table Tilt:* Players shift weight on a balance board in all directions (front-and-back and side-to-side) to tilt a table and guide marbles through holes. The first level is relatively easy - there is only one ball and one hole and shape of the table is simple. The second level suddenly becomes too difficult for many patients - there are two balls and each time one ball falls, the table turns and may shake out the other ball. The fifth level is then extremely difficult for even the typical people - there are bumps that players have to carefully roll the balls over. None of the patients we studied with could pass the fifth level. (Game control: Wii Balance Board)

**Related Patterns:**

- Can be used with *Pick up and Play* and/or *Adjustable Speed* to further ease the learning curve and promote a sense of in control for the player.

- Usually used with *Advancing* to help maintain a sense of progress.
- Can be used with *Optional High-Level Challenge* to help get players engaged.

### B.2.3 Minimized Distraction

**Definition:** Limiting the visual and audio effects in the game can help avoid distracting players with a brain injury from engaged gameplay.

**Problem:** Visual and audio effects are at the core of many games. But with visual and cognitive impairments, people with brain injuries are often overwhelmed by visual and audio stimulation. Visual and audio effects usually provide too much distraction from gameplay for people with brain injuries.

**Solution:** Be careful when using visual and audio effects and only include the necessary ones. Avoid overwhelming the patients.

**Example Game(s):**

- *Wii Fit - Table Tilt:* Players shift weight on a balance board in all directions (front-and-back and side-to-side) to tilt a table and guide marbles through holes. There is no extra animation or sound effect in the game that distracts the player from focusing on the gameplay. (Game control: Wii Balance Board)

**Anti Example Game(s):**

- *Wii Fit - Soccer Heading:* Players shift weight from side to side to head soccer balls that are kicked in, while avoiding hitting foils. The game mechanic is simple but there is a lot of background animation (e.g. a row of servers warming up) and extra sound effect (e.g. audience cheering).

These effects can easily distract players with a brain injury from gameplay. (Game control: Wii Balance Board)

- *Kinect Adventures - 20,000 Leaks*: The player's avatar is in a glass cube underwater. The player positions limbs and head to plug cracks as crabs, fish, and sharks hit the cube; if multiple cracks appear, the player has to plug all of them at the same time. There is too much peripheral animation in this game so that players can get distracted and confused about the goal and required actions of the game. The screen is very crowded, the cracks on the glass cube are very difficult to identify. (Game control: Kinect Sensor)
- *Kinect Adventures - River Rush*: The player's avatar stands on a raft that is moving down a river. The player steps left and right and jumps to control the raft in order to collect points scattered throughout the river. There is a lot of animation and visual effects in this game that is distracting for players with a brain injury. Although the game does not require fast reaction, the fast raft moving animation makes the game look very fast. This sometimes intimidates players. (Game control: Kinect Sensor)

**Related Patterns:**

- Can be used with *Pick up and Play* and/or *Adjustable Speed* to further ease the learning curve and promote a sense of in control for the player.
- *Minimized Distraction* allows a game with an *Enabling Theme* to be more enjoyable by avoiding overwhelming patients.

#### B.2.4 Pick up and Play

**Definition:** Providing easy introductory levels can support a quick grasp of the game's rules and mechanics for players with a brain injury.

**Problem:** People who have had a brain injury are often first-time players and may be only playing the game because their therapists introduced the game. A game that requires a lot of learning will (1) take a lot of therapy session time for the player to learn the game and (2) will be discouraging for first-time players.

**Solution:** Provide easy introduction levels so that the player can easily pickup the game and play. Include activities that are either familiar to most people or very easy to learn.

**Example Game(s):**

- *Wii Fit - Table Tilt:* Players shift weight on a balance board in all directions (front-and-back and side-to-side) to tilt a table and guide marbles through holes. The goal of the game is straightforward. The mechanics are simple and easy to learn. (Game control: Wii Balance Board)
- *Wii Fit - Soccer Heading:* Players shift weight from side to side to head soccer balls that are kicked in, while avoiding hitting foils. The goal of the game is straightforward. The mechanics are simple and easy to learn. (Game control: Wii Balance Board)
- *Kinect Sports - Bowling:* Players play a virtual bowling game against up to three other players. The rules of bowling are familiar to most players. And comparing to Wii Bowling, Kinect Bowling does not require any controllers. The players simply perform the bowling motion to bowl.

There is minimal additional learning in this game. (Game control: Kinect Sensor)

**Anti Example Game(s):**

- *Wii Fit - Obstacle Course*: Players walk in-place and 'jump' (bend and then extend knees) to control the avatar through various obstacles. Players need to control the timing of walk and stop and are required to jump to go over different types of obstacles. Players need to learn how to overcome various types of obstacles, even in the first level. (Game control: Wii Balance Board)
- *Wii Sports - Bowling*: Players play a virtual bowling game against up to three other players or computer opponents. The game is played with the Wii remote. Players need to follow three steps to bowl: (1) push B button, (2) swing their arm, and (3) release the button at a point of the swing when they want to release the ball. Players need to understand this sequence in order to bowl. While the rules may be familiar to the players, the control is not easy to learn. (Game control: Wii Remote Controller)

**Related Patterns:**

- *Pick up and Play* can support *Multiplayer Competition* by allowing newcomers avoid going through a steep learning curve.
- Can be used with *Gentle Challenge Ramp* to further ease the learning curve and promote a sense of in control for the player.
- Can be used with *Minimized Distraction* to further ease the cognitive load of the game and promote a sense of in control for the player.

- *Familiar Theme* sometimes entails familiar rules of the game, and thus facilitates Pick up and Play.

### **B.3 Progress Patterns**

Progress patterns aim to provide the player with BIs a sense of progress through the gameplay experience to encourage continued play.

#### **B.3.1 Advancing**

**Definition:** Players with brain injuries can often get frustrated because they cannot advance in a game due to poor performance. If the players' performance does not affect their advancing in the game world, it can provide a sense of progress to players.

**Problem:** Many patients with brain injuries are casual players - they will stop playing a game when they feel that they are not making progress.

**Solution:** Provide a sense of progress (i.e. introduce something new) regardless of players' performance so that players will be motivated to continue playing the game. Save the play's progress. Don't ask the players to start over from the very beginning when they fail.

#### **Example Game(s):**

- *Kinect Adventures:* Games in the Kinect Adventures focus on score collection. The players can move on to the next level regardless of their performance. This provides novel experiences and encourages player to engage in new game contents. (Game control: Kinect Sensor)

#### **Anti Example Game(s):**



- *Wii Fit - Balance Bubble*: Player's avatar stands in a bubble that runs along a stream. Players shift weight front and back to control the speed of the bubble and shift weight from side to side to steer the bubble; the goal is to reach the finish line while avoiding the riverbank and other obstacles (e.g. a flying bee). Whenever the bubble hits the bank or an obstacle, the player has to start from the very beginning of the stream. (Game control: Wii Balance Board)
- *Wii Fit - Obstacle Course*: Players walk in-place and 'jump' (bend and then extend knees) to control the avatar through various obstacles. Whenever failed to pass an obstacle, the player has to replay the level. This frustrates many patients with a brain injury. (Game control: Wii Balance Board)

**Related Patterns:**

- *Gentle Challenge Ramp* is usually used with *Advancing* to help maintain a sense of progress.
- Usually used with *Optimistic Performance Evaluation* to avoid discouraging players when performance is not good.
- Games with *Optional High-Level Challenge* innately support *Advancing*.

### B.3.2 Optimistic Performance Evaluation

**Definition:** Providing abundant positive feedback can encourage continued play for players with a brain injury.

**Problem:** People who have had a brain injury often perform poorly in commercial games. Further, commercial games often 'punish' players by providing negative performance feedback to encourage players to perform better.

However, too much negative feedback (which is common for people with a brain injury) will discourage players from continued play.

**Solution:** Use punishments sparingly. Instead, provide a lot of positive feedback to encourage continued play. Note that this only has to do with the quality of the feedback - this does not mean that the game should be made less challenging (an appropriate level of challenge is normally desired); see the Challenge Patterns for more info.

**Example Game(s):**

- *Kinect Adventures:* Games in the Kinect Adventures focus on score collection. It is easy for players to get at least a bronze medal with an okay performance. And there is no negative feedback in the game. (Game control: Kinect Sensor)

**Anti Example Game(s):**

- *Wii Fit Balance Games:* When players did not perform well, the Wii Fit games will give out a score and say 'Unbalanced' in the result screen. This is very discouraging (and sometimes offending) for patients who have had a brain injury, especially if they have a balancing issue. (Game control: Wii Balance Board)

**Related Patterns:**

- Usually used with *Advancing* to promote a sense of progress.

## **B.4 Theme Patterns**

Theme patterns propose high-level considerations about creating an appropriate and engaging game theme for BI therapy.

#### B.4.1 Age Appropriate Theme

**Definition:** Patients who have had a brain injury can cover a wide range of age groups. A successful game for brain injury rehabilitation usually has a theme that is appropriate to the players' age group.

**Problem:** Patients who have had a brain injury can range in age from teenagers to very elderly people. Players would not enjoy a game if they feel the theme is too naïve or childish or too serious.

**Solution:** Provide age-appropriate theme according to the target player's age group. If desired (and if possible), cater both young and elderly people's taste. For example, there are people from all age groups who like to dance, but only to their favorite songs. I.e., old and young people have different tastes on music and songs. So providing a collection of hit songs from different periods can cater different age groups.

#### **Example Game(s):**

- *Wii Sports - Golf*: Players play a virtual golf game using the Wii Remote. While the graphics is cartoonish, the theme of the Golf game is familiar to both old (70-80) and young (40-50) players with a brain injury. (Game control: Wii Remote Controller)
- *Dance Central 3*: Players move their body to dance along to the song and try to follow the movement instructions on the screen. In this game, players can dance with songs from different decades ranging from 1970s to 2010s. (Game control: Kinect Sensor)

#### **Anti Example Game(s):**

- *Wii Fit - Penguin Slide*: Players shift weight from side to side to tilt an iceberg and let a penguin that slides on it catch fish jumping out from the water. While it is a very good weight-shifting exercise, many patients complained about the childish theme of the game. (Game control: Wii Balance Board)

**Related Patterns:**

- Games with Age Appropriate Theme can be engaging to be played by patients with friends who are of the similar age, and thus are good candidates for *Multiplayer Competition*.

#### B.4.2 Enabling Theme

**Definition:** An engaging game experience of a patient with a brain injury sometimes comes from a game theme that 'enables' the player to perform activities that he or she cannot do in the real life because of a disability.

**Problem:** Because of physical and cognitive disabilities, people with brain injuries may not be able to perform activities that they were able to enjoy prior to their injury (e.g. sports, dancing). This can lead to pessimism and contribute to skepticism about playing games.

**Solution:** Allow players to do something that they cannot do in real life because of a disability. Borrow elements from activities that the patients enjoy do to before brain injury. Try to elicit the experience that patients would miss because of a brain injury.

**Example Game(s):**

- *Wii Sports or Kinect Sports - Bowling*: Players play a virtual bowling game against up to three other players. Players can play a bowling game

with friends or caregivers. They can pick up this traditional social event through this game. (Game control: Wii Remote Controller or Kinect Sensor)

- *Kinect Sports - Soccer*: Player plays the active soccer player to pass the ball, shoot the ball, and intercept shots at goal (as a goalie). Players who used to play soccer can catch up on this hobby through this game. (Game control: Kinect Sensor)
- *Wii Fit - Ski Jump*: Player skis downhill and is asked to 'jump' (bend and then straighten knees) at a certain point. Players can experience the speed and tense in this game without being able to ski. (Game control: Wii Balance Board)

#### **Related Patterns:**

- *Familiar Theme* and *Enabling Theme* usually work together to create an engaging game environment.

#### B.4.3 Familiar Theme

**Definition:** A game theme that is familiar to the target players with a brain injury can help them feel more related to the game, and thus promote player engagement.

**Problem:** Patients with a brain injury are typically older and thus may not be familiar with the modern video games. They are more familiar with various kinds of physical activities (e.g. sports, physical games) and/or traditional games (e.g. board games, TV game shows).

**Solution:** Replicate or borrow elements from physical activities (e.g. sports, physical games) and/or traditional games (e.g. board games, TV game

shows) to leverage older players' familiarity and satisfy their nostalgia on these activities.

**Example Game(s):**

- *Wii Sports or Kinect Sports - Bowling*: Players play a virtual bowling game against up to three other players. The rules of bowling are familiar to most players. This is a popular game in the hospital that patients spontaneously play with their peer patients in spare time. (Game control: Wii Remote Controller or Kinect Sensor)
- *Wii Sports - Golf*: Players play a virtual golf game using the Wii Remote. Players who used to golf enjoy this game because of familiarity. (Game control: Wii Remote Controller)
- *Family Feud (Wii)*: The TV game show is familiar to most US players. Older patients enjoy being able to play this game. (Game control: Wii Remote Controller)

**Related Patterns:**

- *Familiar Theme* sometimes entails familiar rules of the game, and thus facilitates *Pick up and Play*.
- Games with a *Familiar Theme* to patients are sometimes better candidates for *Multiplayer Competition* because of a gentle learning curve.
- *Familiar Theme* and *Enabling Theme* usually work together to create an engaging game environment.

## **APPENDIX C. DESIGNER INTERVIEW RESEARCH MATERIALS**

The designer interviews should be semi-structured and follow this script and guide.

### **C.1 Greetings and Introduction**

Hello, \_\_\_\_\_. This is Jinghui from DePaul University. *Greetings*

Is this still a good time to talk? *If so:* Thank you again for being able to help us in this project.

*Gather consent.*

Introduce agenda:

- 20 min: talk about how you approach designing games, especially games for health
- 20 min: talk about game design patterns

### **C.2 Demographic Questions**

1. How many years have you worked in the game development field?
2. What is the company/organization you are currently working in?

3. How many games have you designed?
4. How many of them would you consider as games for health?  
*Games for health are games that focused on improving physical and/or mental health and well being of the players.*

### **C.3 Game Design Experiences and Approaches**

1. In the context of your most recent project, can you talk about how you design games for health?
2. Please describe your most successful project of game for health.
  - Who are your target players?
  - What is the aim of the game (the desired player outcomes)?
  - What do you think are the key elements that made it very successful?
3. Please describe a not so successful/the least successful project.
  - Who are your target players?
  - What is the aim of the game (the desired player outcomes)?
  - What do you think are the key elements that made it not so successful?
4. How do you explore the needs (and attributes) of your target players when designing a game for health?
  - What kinds of method did you use?
5. How did you evaluate the games you designed?



- What kinds of method did you use?
6. What would you consider is the biggest challenge in games for health design?
    - In the last project, how did you mitigate them?

#### **C.4 Game Design Tools**

As you probably know, one of the goals of this project is that we are trying to create a tool to help game designers create better games for health – currently focusing on brain injury rehabilitation. This work is based on the data we collected over the past three years with therapists from two rehabilitation hospitals in Chicago. We collected data about over 300 therapy sessions in which commercial games were used in brain injury rehabilitation therapies. To help us ideate the design of the tool, we have a few questions about the other kinds of tools you have used (if any). We are talking about a broad definition of tools that include conceptual, physical, or digital artifacts that supported your work.

1. What kinds of tools have you used for *designing* games for health?
2. What kinds of tools have you used for *evaluating* games for health?
3. What were the most useful tools?
  - For each, talk about a particular experience using the tool.
4. What were the least useful tools?
  - For each, talk about a particular experience using the tool.
5. What would be an ideal tool for you in creating games for health?

## C.5 Game Design Patterns

As another goal of this project, we are also creating game design patterns for games for health. It is possible that patterns will be at the core of the tool that we are creating. So we are also interested to know your experience and opinion on game design patterns.

1. How familiar are you with game design patterns?
  - Scale 0 – 5: Not familiar at all – Extremely familiar
  - If familiar (rating >3):
    - Have you used game design patterns in your work?
      - If so, tell us about your experience using game design patterns.
      - If not, why not?
  - If not familiar:
    - *Introduce the concept of game design patterns to the participant.*

Next I will show you a couple of initial patterns that we have created. They are very preliminary. We will take your feedback and improve them.

*Ask the participant to look at the example game design patterns document.*

We would like you to look at each example pattern and give us some feedback. To explore your feedback, imagine a scenario in which you were working with an occupational therapist who wanted to promote bilateral hand use using a game.

2. For the first example pattern:

- Describe two aspects that you like about it.
  - Describe two aspects that you do not like about it.
3. For the second example pattern:
- Describe two aspects that you like about it.
  - Describe two aspects that you do not like about it.
4. Now that you've seen some of our example design patterns, how do you think game design patterns like these would influence your work of designing \_\_\_\_\_?

## **C.6 Wrap Up**

That is it all of my questions. Thank you very much!

Is there anything you want to add?

Do you have any question for me?

Thank you again.

## **APPENDIX D. USABILITY STUDY RESEARCH MATERIALS**

### **D.1 Greetings and Introduction**

Hello, \_\_\_\_\_. This is Jinghui from DePaul University. *Greetings*

Is this still a good time to talk? *If so:* Thank you again for being able to help us in this project.

*Gather consent.*

As you know, we have created a set of game design patterns for brain injury rehabilitation. The tool is aimed at helping game designers understand those patterns and choose the patterns. The goal of this session is to test the usability of the tool.

Introduce agenda:

1. Perform four tasks.
2. Additional questions about feedback on certain pages and your experience.

### **D.2 Perform Prescribed Tasks**

Several points to explain:

- This is a very low-level prototype – it is not ‘working’ and is not a visual design.

- You are not tested. There is no right or wrong way of performing any tasks and no right or wrong answers to any questions. The tasks are not timed.
- You may skip any tasks if you want.
- We ask you to think aloud – try to explain your action and thoughts as detail as possible.
- Introduce interaction of Morae – ‘Start task’, ‘End task’, ‘Show instructions’.

#### D.2.1 Task 1

Go to the page **Background Info about Therapy-Centered Game Design**. From the page, get information about therapists’ motivation for using games in brain injury rehabilitation.

- Tell us about this piece of information you acquired.

#### D.2.2 Task 2

Scenario: Suppose you were designing a game aiming at improving both **Hand-eye coordination AND Attention and concentration** for stroke patients.

- Use the tool to choose two game design patterns that may help you design the game.
- Use the game design patterns you chose to generate some game design ideas that may help you design the game.
  - Tell us about the game design ideas that you have generated this way, if any.

### D.2.3 Task 3

Scenario: Suppose you were designing a game for stroke patients and playtesting of an early prototype suggested that the target players (stroke patients) were not very engaged because they did not have ‘**a sense of being in control.**’

- Use the tool to choose two game design patterns that may help you address this issue.
- Read the detail information about the two Game Design Patterns that you chose in the previous step. While you are reading, try to identify some characteristics of the target players (stroke patients) you would need to consider when addressing this issue.
  - Tell us about the target player characteristics you identified this way, if any.

### D.2.4 Task 4

Identify the game design patterns that could support the pattern **Optional High-level Challenge** (a pattern focusing on player experience)

- Call out patterns you identified this way, if any.

### **D.3 Provide Feedback on Certain Pages**

1. 'View by' list for Efficacy-centered patterns
  - Which view is the most useful view?
  - Which view is the least useful view?
  - For the most useful view, consider the page layout and the content presented, discuss:
    - Two things that you like
    - Two things that you do not like
2. 'View by' list for Experience-centered patterns
  - Same questions as previous
3. Pattern detail page: Consider the page layout and the content presented, discuss:
  - Two things that you like
  - Two things that you do not like
4. Look at an example game of a design pattern
  - What do you expect the image would be about?
  - What do you expect the video would be about?
  - Which one is more useful?
  - What do you expect the therapist comments would be about?

5. Background information page: Consider the page layout and the content presented, discuss:
  - Two things that you like
  - Two things that you do not like

#### **D.4 Post-Test Questions**

1. Overall speaking, tell us what you think about this system?
2. What are the most useful features for you?
3. Is there any feature that you think would be useful but is missing?

#### **D.5 Wrap up**

That is it all of my questions. Thank you very much!

Is there anything you want to add?

Do you have any question for me?

Thank you again.



## APPENDIX E. GAME DESIGN WORKSHOP

### RESEARCH MATERIALS

#### E.1 Greetings and Introduction

*Greetings and introduce the lab space (introduce the note takers, if any).  
Sit the participants in front of the computer.*

*Gather consent.*

*If includes therapist:* Let's have a round of self-introductions. Tell us (1) your name, (2) what you do, and (3) one piece of interesting information about you.

*Introduce the goal of the session:*

- *If use tool:* To understand how the tool works in a realistic game design process.
- To understand the dynamics in which a designer and a therapist interact to create a game.

We ask you *work together (if includes therapist)* to create a game design idea based on a scenario and write a game design pitch for the idea. The game can be on any platform – it can be a digital game, a board/card game, or an activity game. *If use tool:* We want you to use the tool as much as possible. We will have questions about your experience using the tool at the end.

Do you have any questions so far?

Let's get started by viewing a video that briefly introduces the background about game design for brain injury therapy. Play the introduction video:  
[http://gametherapy.cstcis.cti.depaul.edu:8888/intro\\_video.html](http://gametherapy.cstcis.cti.depaul.edu:8888/intro_video.html)

*If use tool: Provide a tutorial of the tool.*

Do you have any questions at this point?

*Hand the scenario to the participants.* We have markers and papers here for you to use. And please feel free to enjoy the refreshment on the table. If you have any questions, just let us know.

*Leave the room and enter the observation room.*

## **E.2 Game Design Requirements**

Create a **written design pitch** about a game (or a set of mini-games) for the following target player and rehabilitation goals.

### **Target Player Profile:**

Rena is 55 years old. She recently had a stroke that had influenced the right side of the body. Her right arm has limited range and she does not trust her right leg to stand and walk. In addition, the stroke has impaired her attention and concentration abilities, although she is currently able to follow sequential commands.

Prior to stroke, Rena was an active reader and writer and liked to collect antique dolls. She was also an active cyclist and used to cycle regularly with her

husband to explore parks. Occasionally, she also enjoyed playing mobile games; her favorite games were Plants vs. Zombies and Cut the Rope.

**Rehabilitation Goals:**

The main goal is to improve the **standing and walking** abilities of the patient.

A secondary goal is to improve the **attention and concentration** abilities.

**Game Design Pitch:**

Create a two-page game design pitch to illustrate your game's concept and gameplay details.

**E.3 Debrief Questions**

E.3.1 For Game Designers

1. Please briefly describe your process ideating this game.
2. Overall, how satisfied were you with the game ideation process?
3. What were the main sources that inspired you during the game ideation process?
4. If interacted with a therapist:
  - How satisfied were you with interacting with the therapist during the game ideation process?
  - If also used the tool:

- How useful do you think the tool at helping you interact with the therapist?
5. If used the game design tool:
- Overall speaking, how do you feel about the tool?
  - How useful do you think the system at helping you in the game ideation process?
  - What are the most useful features for you?
  
  - What game design patterns did you use in your final design?
  - What other game design patterns did you consider during the game ideation process?
  - How useful do you think the following information in a pattern detail info page?
    - Pattern definition
    - Problem description
    - Solution description
    - Related patterns
    - Example games
      - Snapshot image
      - Text description

- Therapists comments
  - How can we improve these game design patterns and the tool?
6. Is there anything you would like to add?

### E.3.2 For Therapists

1. Please briefly describe your process creating this game.
2. Overall, how satisfied were you with the game brainstorming process?
3. How satisfied were you with interacting with the game designer during process?
4. If used the game design tool:
  - Overall speaking, how do you feel about the tool?
  - How useful do you think the system at helping you in the game brainstorming process?
  - How useful do you think the system at helping you interact with the game designer?
  - What are the most useful features for you?
  - How useful do you think the following information in a pattern detail info page?
    - Pattern definition
    - Problem description
    - Solution description

- Related patterns
  - Example games
    - Snapshot image
    - Text description
    - Therapists comments
  - How can we improve these game design patterns and the tool?
5. Is there anything you would like to add?

## APPENDIX F. GAME EVALUATION

### RESEARCH MATERIALS

#### F.1 Greetings and Introduction

Hello, \_\_\_\_\_. This is Jinghui from DePaul University. *Greetings*

Is this still a good time to talk? *If so:* Thank you again for being able to help us in this project.

*Gather consent.*

Introduce the goal: We are asking you to help us evaluate game design ideas that were created during game design workshops. The games were all designed for a brain injury rehabilitation scenario.

I will ask you to read some game design idea documents and then rate the game ideas based on a set of criteria. There are six game ideas we are going to evaluate during this session.

*For designers:* Play the video that introduces background about game design for BI therapy:

- [http://gametherapy.cstcis.cti.depaul.edu:8888/intro\\_video.html](http://gametherapy.cstcis.cti.depaul.edu:8888/intro_video.html)

There are several points to emphasize about the game idea documents:

- The documents were all created within 1.5 hours. They are pitches of ideas about a game – they are not fully designed games. Please

evaluate based on the ideas and their potential – don't have to worry about the presentation or writing.

- I didn't design the games. I am not attached to the game ideas at all. So please feel free to provide honest feedback. And at the same time, I will not be able to explain the game ideas to you.
- *For designers:* Please only focus on the player experience of the game and don't have to worry about therapy value.

Let's take a look at the scenario that the designer focused on when creating those game ideas. *Ask participants to spend one minute to read the design scenario.*

Let's then take a look at the evaluation form that we will be using. *Walk the participants through the evaluation questions.*

Do you have any questions at this point? *If not:* We will start the evaluation.

## **F.2 Evaluation**

*For each design idea, give participants five minutes to read the design document, then ask questions on the evaluation form.*

### **F.2.1 Evaluation Questions for Designer Evaluators**

1. To what extent do you agree or disagree with the following statement?  
Rate using a 5-point scale (1 – Strongly Disagree, 5 – Strongly Agree):
  - The goal of this game is clear.
  - The game is able to provide relevant feedback to the player's actions.



- The mechanics of this game is unique and innovative.
  - The theme of this game is appropriate for the target player.
  - The theme of this game is unique and innovative.
  - This game would be engaging for the target player.
  - This game would be re-playable for the target player.
2. Provide an overall score for this game (from 0 to 10)
  3. Name one or two positive aspects of this game
  4. Name one or two negative aspects of this game

#### F.2.2 Evaluation Questions for Therapist Evaluators

1. To what extent do you agree or disagree with the following statement?  
Rate using a 5-point scale (1 – Strongly Disagree, 5 – Strongly Agree):
  - This game would be effective at addressing the main therapy goal (standing and walking) for the target player.
  - This game would be effective at addressing the secondary therapy goal (attention and concentration) for the target player.
  - The physical difficulty of this game is appropriate for the target player.
  - The cognitive difficulty of this game is appropriate for the target player.
  - The theme of this game is appropriate for the target player.
  - This game is appropriate to be played in an in-patient therapy session.

- This game is appropriate for the target player to be played at home.
  - This game would be engaging for the target player.
2. Provide an overall score for this game (from 0 to 10)
  3. Name one or two positive aspects of this game
  4. Name one or two negative aspects of this game

### **F.3 Post Evaluation Questions**

#### F.3.1 For game designers

1. Overall, what do you feel about these game ideas?
2. Which games were the most impressive? Why?
3. Which games were the least impressive? Why?
4. Generally speaking, what do you feel are the most important factors associated with the success of the games designed for brain injury rehabilitation?
5. Was there anything you would have liked to see included in the games but was missing in all the games presented?

#### F.3.2 For therapists

1. Overall, what do you feel about these game ideas?
2. Which games were the most impressive? Why?
3. Which games were the least impressive? Why?

4. Generally speaking, what do you feel are the most important factors associated with the success of the games designed for brain injury rehabilitation?
5. Was there anything you would have liked to see included in the games but was missing in all the games presented?

#### **F.4 Wrap up**

That is it all of my questions. Thank you very much!

Is there anything you want to add?

Do you have any question for me?

Thank you again.

## APPENDIX G. DESIGNER INTERVIEW CODEBOOK

### G.1 Attributes

This is information that does not need inter-rater reliability

#### G.1.1 Game Type

Code for the game type(s) the designers focused on.

*G.1.1.1 Board/card game*

*G.1.1.2 Digital game*

*G.1.1.3 Physical activity game*

Game involves physical body movement or is played in a real world space

#### G.1.2 Game Focus/objectives

Code for the focus/objectives the designers explored in their games.

*G.1.2.1 Promoting healthy behavior*

Code when participant mentioned they designed a game that targets promoting healthy behavior.

E.g. promote healthy sexual behavior in teens, promote healthy eating, prevent heart failure, prevent/manage diabetes, promote healthily safe behavior, promote good hygiene practice

*G.1.2.2 Addressing a mental health condition*

Code when the game directly targets improvement of a mental health condition (e.g. stress, anxiety) of the players.

*G.1.2.3 Increasing awareness/empathy on certain health conditions*

Code when participant mentioned they designed a game that targets increasing awareness/empathy on a health condition among caregivers and/or the general public.

E.g. increase awareness/empathy of depression, ADD, bipolar, OCD, etc.

*G.1.2.4 Supporting conversations around health related issues*

Code when the game is aimed at supporting conversation/communication around a sensitive health related issue (e.g. death/end of life, sex and sexuality among teens)

*G.1.2.5 Physical activity*

Code when the game aims at physical exercise

G.1.3 Tools Used

Code under **Structure: Tools - Used**

*G.1.3.1 Playtest methods*

Code when participants described playtesting or similar game user evaluation methods as a tool.

Also code when participants mentioned specific playtesting methods, such as observation, survey, or focus groups.

#### *G.1.3.2 Published frameworks about game design*

Code when participants described published game design frameworks (e.g. Jesse Schell's lenses) as a tool to support game design.

#### *G.1.3.3 Published frameworks about the domain*

Code when participants mentioned that they used published frameworks about the subject matter (e.g. learning, behavior change) as a tool to support game design.

Also code when participants described using established metrics or frameworks to support game evaluation.

#### *G.1.3.4 Prototyping tools*

Code when participants described specifics about prototyping methods or tools; e.g. paper prototyping, using physical objects or text documents/spreadsheets for prototyping.

#### *G.1.3.5 Internal frameworks about serious game design*

Code when participants mentioned they developed internal frameworks to support their game design or game evaluation.

#### *G.1.3.6 Design philosophy*

Code when participants considered the design process, design thinking, or brain storming methods as a tool.

#### *G.1.3.7 Existing games*

Code when participants considered existing games as a tool to support inspiration and/or communication.

## **G.2 Contents**

### G.2.1 Success [Criteria]

Code under **Structure: Success**

Code when described specifics about **criteria** or **standards** they considered when determining success of a game for health.

**Note:** We focus on the criteria not the successfulness; i.e. a criterion can appear when talking about either successful games (met the criteria) or unsuccessful games (did not meet the criteria). For example, a participant could have said that a game was really successful because it successfully embedded the fun factors in the serious content, while another participant could have said that a game was not successful because it failed to achieve that; but they are talking about the same thing – they both consider a balance between engagement and efficacy in the game is a criterion to determine success.

#### *G.2.1.1 A balance between engagement and efficacy*

Code when participants explicitly mentioned achieving this balance when talking about successful games, or failing to achieve this balance when talking about unsuccessful games.

Also code when mentioned embedding engagement (or failing to embed engagement) in the game to support the serious contents.

DO NOT code if did not talk about engagement or did not talk about efficacy.

Keywords: balance; effectiveness; efficacy; engagement; fun factor; embedding

#### *G.2.1.2 The game's effectiveness at addressing the objectives*

Code when participants mentioned meeting the game's serious objectives as a criterion of success but did not explicitly mention the balance between the fun and the seriousness.

Keywords: efficacy; effective; it worked/did not work; evidence

#### *G.2.1.3 Impact/adoption/publicity*

Mentioned achieving some impact, a relatively wide adoption, or a certain level of publicity as a criterion of success.

Keywords: people loved it; used widely; won some awards; people talk about it a lot; sustainability

#### *G.2.1.4 Size of the project*

Code when participants mentioned a successful game as big or an unsuccessful game as small.

### G.2.2 Success [Factors]

Code under **Structure: Success**

Code when described specifics about **factors that contributed to** the successfulness or unsuccessfulness of a game for health – the factors that helped them to achieve the success criteria or led to failure of achieving the success criteria.

**Note:** Similar to Success [Criteria], a Success [Factor] can appear when talking about either successful games or unsuccessful games.



#### *G.2.2.1 Stakeholder cooperation/communication*

Code when mentioned good cooperation and partnership with the client or subject matter experts as a factor for successful game projects, or mentioned a bad cooperation (e.g. conflict of interest between designers and subject matter experts) led to unsuccessfulness.

Also code when mentioned that subject matter experts have provided useful information about the domain and the user; or the lack of subject matter experts' help have led to unsuccessful games.

Keywords: partnership; cooperation; relationship building; client; subjective matter experts

#### *G.2.2.2 Target player interaction*

Code when mentioned one of the following things when talking about a success factor:

- Talk with target players to understand the characteristics and needs
- Participatory design/co-design with target players
- Playtest with target players
- Interacting with target players have provided insightful information

Keywords: target player; playtesting; participation; interview

#### *G.2.2.3 Domain/user research – General*

Code when mentioned domain or user research (or the lack of it) has led to successful (or unsuccessful) games, but did not describe the specifics (e.g. methods) about the domain/user research.

Keywords: domain analysis; understand user demographics

#### *G.2.2.4 Good game design*

Code when mentioned **general** game design elements (e.g. narratives, challenge, etc.) as a success factor.

Also code when mentioned **specific** game design choices (e.g. certain game mechanics or game elements) have made a specific game successful.

Examples of good game design can include:

- Creative game design that captured the players' interest and/or helped achieve the efficacy
- The game as an authentic simulation of a real-life experience/situation so it facilitated understanding/empathy/familiarity
- Novel game design elements, including novel input methods
- Successful game mechanics or game design elements (e.g. narratives)

#### *G.2.2.5 Iteration*

Code when explicitly mentioned design iteration has lead to better games.

Also code when talked about an **example** in which iteration resulted in a better game or a better version.

### G.2.3 Challenge

Code under **Structure: Challenge**

#### *G.2.3.1 Combining engagement and the seriousness*

Code when mentioned it is challenging to achieve the balance between engagement and efficacy.

Keywords: make it still feel like a game; have to achieve the purpose; intrinsic vs. extrinsic motivation; translate the serious content into gameplay

### *G.2.3.2 Consolidating interests of subject matter experts and game designers*

Code when mentioned that designers have to deal with the different mindset/interests/motivations between the subject matter experts and the designers.

Or mentioned it is often challenging to communicate with subject matter experts.

Keywords: disagreement; compromise; consensus; don't speak the same language

### *G.2.3.3 Evaluating efficacy*

Code when mentioned that it is usually difficult to measure the efficacy of games for health, because:

- A proper measurement needs resources like time, money, and/or committing partners.
- A formal evaluation is usually done when the game is finished and/or it takes too much time to feed iteration.
- It is difficult to define the proper metrics to measure efficacy.

Keywords: difficult to show efficacy; difficult to measure

### *G.2.3.4 Understanding the domain and target players*

Code when mentioned one of the followings:

- The domain of game for health is usually unfamiliar to designers
- Target players of games for health may not be typical gamers

- There are constraints in the domain that the designers need to understand and consider (e.g. designing game for kids with mature subject matter)
- Picking the appropriate objectives of the game for the domain requires a lot of effort

#### *G.2.3.5 Limited resource*

Code when mentioned games for health projects usually have to deal with limited resource (e.g. time and money).

#### *G.2.3.6 Achieving lasting impact/interest*

Code when mentioned that it is challenging for games for health to (1) achieve lasting and sustainable impacts or (2) maintain lasting player interest.

Keywords: lasting change; sustainable; novelty wears off quickly

#### *G.2.3.7 Stigma/stereotypes associated with gaming*

Code when mentioned a challenge for games for health is to deal with the stereotypical stigma associated with gaming (e.g. games are not serious or are non-active).

### G.2.4 Before prototype - Domain Research [Goal]

Code under **Structure: General approach** AND **Structure: Domain research and game evaluation**

Code when (1) explicitly mentioned the goal of the domain research or (2) when talking about how they started a game for health project (because domain research is usually their first steps).

**Note:** We define Domain Research as methods participants used to understand the subject matter topic or the needs of the target players. This is done **before a**

**prototype is created** – usually the first step they took when starting a game for health project.

*G.2.4.1 Determine game's objectives and/or desired outcomes*

Code when participants mentioned determining the objectives of the game or the desired player outcomes as one of their first steps or the goal of domain research.

Keywords: identifying a problem; measurement of success; desired player outcomes

*G.2.4.2 Support brainstorming/prototyping*

Code when participants mentioned specifics about how domain research supported ideating or brainstorming the initial game mechanics, game contents, or general game design ideas.

Also code when mentioned domain research directly led to creation of game prototypes.

Do NOT code if participants only mentioned that brainstorming/prototyping happened after domain research. They need to explicitly talk about how domain research supported brainstorming/prototyping.

Keywords: prototyping; brainstorming; kick-start

*G.2.4.3 Understand the context*

Mentioned one of their first steps or the goal of domain research is to (1) understand the subject matter topic or (2) understand the barriers/challenges in the domain.

Keywords: problem; barriers; challenges; constraints

#### *G.2.4.4 Understand attributes of target players*

Mentioned understanding characteristics or attributes (e.g. abilities of the players, players' gaming experience) of the target audience of the game as the goal of domain research.

#### *G.2.4.5 Ensure accuracy/authenticity*

Mentioned doing domain research to ensure the theme or content of the game is an accurate/authentic reflection of the domain in real-life.

Keywords: authentic; accurate

### G.2.5 Before prototype - Domain Research [Method]

Code under **Structure: General approach** AND **Structure: Domain research and game evaluation**

**Note:** We define Domain Research as methods participants used to understand the subject matter topic or the needs of the target players. This is done **before a prototype is created** – usually the first step they took when starting a game for health project.

#### *G.2.5.1 Interact with target players*

Code when participants mentioned they directly interacted (via e.g. interviews, informal talks, or co-design) with target players prior to creating a prototype to understand the domain and player needs.

#### *G.2.5.2 Get support from subject matter experts*

Code when participants mentioned they worked with subject matter experts or partnered with a research institute to understand the domain and player needs.

Also code when mentioned the game was based on a research project.

#### *G.2.5.3 Read research or analyze domain*

Code when mentioned that they read materials such as research papers or books to understand the domain.

Also code if they mentioned the broad concept of domain analysis but did not specify the methods.

Keywords: drew from the body of research; domain analysis

#### G.2.6 After prototype - Evaluation [Goal]

Code under **Structure: General approach** AND **Structure: Domain research and game evaluation**

**Note:** Evaluation is conducted **after a game prototype is made** (can be a very early prototype, e.g. paper prototype). It can be done with or without users.

##### *G.2.6.1 Test the efficacy*

Code when participants mentioned they or researchers they cooperated with conducted evaluation to test the effectiveness or the subject matter factors.

Code when mentioned testing to see "if the game works" when it clearly means if it is effective.

##### *G.2.6.2 Test the engagement/gameplay*

Code when mentioned they evaluated the games to test the gameplay or to gather player feedbacks on the gameplay.

Also code when mentioned they conducted evaluation to measure general “engagement” or to make the game more “engaging”.

Do NOT code if only mentioned they conducted evaluation to see “how people responded” or “reacted”, but not clear if it is about engagement.

Keywords: engaged, engaging

#### *G.2.6.3 Test other game attributes including narratives and artwork*

Code when mentioned they tested aspects of the game other than gameplay (e.g. theme, story, characters, artwork, etc.).

#### G.2.7 After prototype - Evaluation [Method]

Code under **Structure: General approach** AND **Structure: Domain research and game evaluation**

**Note:** Evaluation is conducted **after a game prototype is made** (can be a very early prototype, e.g. paper prototype). It can be done with or without users.

##### *G.2.7.1 Playtest – not specified*

Code when they mentioned playtesting but did not specify if it is based on observation, interview, or survey.

Keywords: test, playtest, focus test

##### *G.2.7.2 Playtest – observation-based*

Code when they mentioned the playtesting is based on observing the participants’ behavior

Keywords: observe, watch, see

##### *G.2.7.3 Playtest – interview/conversation/focus group*

Code when they mentioned they directly talked with the participants or asked questions during, pre, or post the playtest session.



Keywords: interview, conversation, focus group questions, ask them to talk about it

#### *G.2.7.4 Playtest – survey*

Code when they mentioned they used survey in playtesting sessions or used online survey or telephone survey to evaluate the games.

Keywords: survey, questionnaire, SurveyMonkey

#### *G.2.7.5 Playtest – remote test*

Code when they mentioned that they send the game to the participants to playtest or use telemetry data to evaluate the game.

#### *G.2.7.6 Formal research studies*

Code when mentioned formal research studies were (or are being) conducted to evaluate the game (usually by collaborating subject matter experts to test efficacy).

#### *G.2.7.7 Subject matter expert review/feedback*

Code when mentioned they got expert feedback based on subject matter expert review of the game.

### G.2.8 After prototype - Evaluation [Concerns]

Code under **Structure: General approach** AND **Structure: Domain research and game evaluation**

#### *G.2.8.1 Early and/or often*

Mentioned they conducted playtestings early (e.g. on paper prototypes, by the second week) and/or often (e.g. every week/every two weeks, embedding playtesting in Sprints (Agile process)).

Keywords: quick prototype, paper prototype

#### *G.2.8.2 Test with wide range of target players*

Mentioned they conducted playtesting of a game with different target user groups (e.g. kids and adults) or playtested with a large amount of players in order to get diverse feedback.

Keywords: different groups of target users; across the board; diverse

#### *G.2.8.3 Obscuring the purposeful goal in playtesting*

Mentioned that they intentionally concealed or obscured the health or learning related goal of the game from the participants during playtesting – to see if the goal emerges from play.

Keywords: no priming; whether the experience come across; ask about the goal/target player of the game after playtesting

#### *G.2.8.4 Group/social testing*

Mentioned that they conducted playtesting with multiple participants at a time to encourage socialization and feedback.

## **APPENDIX H. GAME THERAPY SESSION OBSERVATION CODEBOOK**

This codebook was used for self-reference only – it was not used to evaluate inter-rater reliability.

### **H.1 Engagement Level (Magnitude)**

Code for patient's engagement level from 1 to 5, one being very unengaged, five being very engaged.

The default engagement level is 3. Add or subtract values based on the following criteria (if over 5, make it 5; if below 1, make it 1):

- +0.5 if the patient smiled/laughed because of enjoyment (Do not add the point if smiled/laughed because of embarrassment)
- +0.5 if the patient verbally expressed enjoyment (e.g. "This is really fun")
  - +1.5 instead if the patient verbally expressed enjoyment more than twice
- +1 if the patient wanted to play the game more than twice in a row (Therapists usually ask a patient to play the same game twice)
- -1 if the patient did not want to play the game again after the first try

- -0.5 if the patient verbally expressed un-enjoyment, frustration, or boredom (e.g. “This is too much...”, “Oh my gosh!”, or apologized for bad performance)
  - -1.5 instead if the patient verbally expressed un-enjoyment, frustration, or boredom more than twice

## **H.2 Physical Support**

Code for the physical support therapist provided to the patient while the patient played the game

### H.2.1 Protection

Code when the therapist stood close to the patient, put one or two hands on or close to patient’s body, and/or held on to the gait belt

### H.2.2 Scaffolding

Code when the therapist provided hand-on-hand support (because of physical needs), helped patient move the body, and/or bore part of the patient’s weight

## **H.3 Cognitive Support**

Code for the cognitive support therapist provided to the patient while the patient played the game

### H.3.1 Rules

Teaching the rules or elements of the rules (e.g. the bee in the Bubble game) of the game (cognitive parts of how to play the game) – or asking the patients to read the rules/going through the tutorial

### H.3.2 Movement

Code when provided support so that the patient understands the “correct” movements to play the game.

- Before the game, teaching the correct physical movements needed (e.g. how to control body parts)
- During play provide instructions on physical movements – game control (only code when providing instructions about the correct movement to play the game)
- After play, tell the patients what they didn’t do right in movements (e.g. “what I notice you are kind of doing there was ... But ....”)

DO NOT code when providing instructions about the timing of a movement or providing a suggestion on a movement (e.g. “you can use both hands for this”) – code “Strategy/tactic” instead

### H.3.3 Strategy/tactic

Code when provided instructions, suggestions, or feedbacks to help patients make decisions in the game (including decisions on movement timing).

- Provided tactic instructions while playing (e.g. “do this, now!”, “go, go, go”).
- Provided props/asked questions to guide patient’s decision making.
- Provided suggestions after play (e.g. “you’ve got to do this when it comes like that...”).

#### H.3.4 Non-Play UI

Guiding the patient going through the setup; providing instructions on non-play UI movements (e.g. “move back a little bit”)

#### H.3.5 Demo

Show the patient how to play by providing a demonstration play

### **H.4 Reinforce**

Code about what therapists do to reinforce therapeutic effectiveness of the games

#### H.4.1 Emphasize

Emphasized certain postures/movements and/or reflected in therapeutic goals (e.g. standing [“nice straight back”], balance); asked the patient to pay attention to these movements or goals

#### H.4.2 Additional Movements

Required additional movements including requirements to alternate sides (work on non-dominant side) or do different kinds of movements/poses (e.g. Ask them to sit and stand playing bowling).

#### H.4.3 Additional Devices/Equipment

E.g. used foam board; used yoga balls

### **H.5 Playing Position**

Code for the position of the patient – whether he or she stands or sit when playing the game

- Standing independently

- Standing with therapist's protection
- Standing with therapist's support
- Standing with walker
- Standing with cane
- Sitting

## **H.6 Game setup**

Code for who set up the game

- Therapist set up
- Researcher set up
- Patient set up under instruction
- Patient set up independently

## APPENDIX I. GAME DESIGN WORKSHOP CODEBOOK

### I.1 Coding Methods

#### I.1.1 Code for activities

Most codes are about activities – what the participants were doing. Code the activities in 10-second increments. In each 10-second time slice, code for the **predominant** activities of the designer and the therapist (if present) by typing “1” in the corresponding cell in the excel file.

A predominant activity is defined as the main activity that usually takes the majority of time during the 10-second time slice.

Coding multiple activities in a same time slice is allowed if they can all be considered predominant.

During activity coding, we do not differentiate activities of the designer and the therapist unless otherwise specified; i.e. we are mostly focused on the activity itself, rather than who is performing the activity.

- For example, if the designer is writing/sketching while the therapist is reading the scenario, code both “Writing/sketching” AND “Reading the scenario”
- As another example, code “Typing/editing” when either the designer or the therapist is typing/editing



### I.1.2 Code for events

Some codes are about occurrence of events. When coding events, type “1” in the 10-second time slice during which the event happens/begins to happen.

All event codes start with “Event”. Otherwise, the code is an activity code.

If the occurrence of the event lasted longer than 10 second (e.g. designer asked a lengthy question), code only at the beginning of the event (e.g. when the designer begins to ask the question).

## I.2 Codes

### I.2.1 Reading the scenario

Code when the predominant activity (in the current 10-second time slice) of the designer or the therapist is to look at the scenario sheet.

### I.2.2 Thinking in silence/out load

Code when the predominant activity (in the current 10-second time slice) of **BOTH** the designer **AND** the therapist is to think.

### I.2.3 Writing/sketching/taking notes

Code when the predominant activity (in the current 10-second time slice) of the designer or the therapist is to:

- Write or sketch on a piece of paper, OR
- Type notes (notes about the scenario or preliminary thoughts that are clearly not the final design pitch) on the computer

#### I.2.4 Typing/editing the pitch

Code when the predominant activity of the designer or the therapist is to type out or edit the design pitch.

#### I.2.5 Searching the Internet

Code when the predominant activity is to search and browse on the Internet (e.g. about an existing game or about game platforms).

#### I.2.6 Communicating/discussing

When the predominant activity is to discuss about something, code the following events and discussion topics.

**Important:** DO NOT code when it is clear that a participant is talking to him or herself, or just thinking aloud (e.g. when reading, taking notes, or typing). Only code when talking has the purpose of communicating/discussing.

**Note:** Do not directly code on 6. Code on 6.a.1 to 6.c.12, then 6 is automatically calculated.

##### *I.2.6.1 Designer events*

##### *(a) Event: Designer asked a question to acquire info*

Code when the designer begins to ask a “substantial” question – a question aimed to acquire information.

Do NOT code questions that are a part of a suggestion or concern (see below).

Do NOT code “unsubstantial” questions such as “Does it make sense?” “Blablabla, right?”

##### *(b) Event: Designer suggested an idea*

Code when the designer begins to suggest an idea.

**Note:** Sometimes a suggestion can include a question; e.g. “Blablabla. How do you think about it?” In that case, DO code it as a suggestion and DO NOT code it as a question.

*(c) Event: Designer voiced disagreement or concern*

Code when the designer begins to voice a disagreement or concern about an idea emerged from discussion

**Note:** Sometimes a concern can include a question. In that case, DO code it as a concern and DO NOT code it as a question.

*(d) Event: Designer explained things (without prompt)*

Code when the designer begins to explain something without being prompted/asked by the therapist

#### *1.2.6.2 Therapist events*

*(a) Event: Therapist asked a question to acquire info*

Code when the therapist begins to ask a “substantial” question – a question aimed to acquire information.

Do NOT code questions that are a part of a suggestion or concern (see below).

Do NOT code “unsubstantial” questions such as “Does it make sense?” “Blablabla, right?”

*(b) Event: Therapist suggested an idea*

Code when the therapist begins to suggest an idea

**Note:** Sometimes a suggestion can be in the form of a question (e.g. “Blablabla. How do you think about it?”) In that case, DO code it as a suggestion and DO NOT code it as a question.

*(c) Event: Therapist voiced disagreement or concern*

Code when the therapist begins to voice disagreement or concern about an idea emerged from discussion

**Note:** Sometimes a concern can include a question. In that case, DO code it as a concern and DO NOT code it as a question.

*(d) Event: Therapist explained things (without prompt)*

Code when the therapist begins to explain something without being prompted/asked by the designer

*1.2.6.3 Discussion topics*

*(a) Topic: BI therapy practice*

Code when the designer asked and/or the therapist explained about the general goal and practice of BI therapy (e.g. what the therapist normally does when working with a patient who had a BI).

Also code when discussed about what the therapist normally does when working with a particular patient persona (e.g. the persona in the design scenario) or working on a particular goal.

*(b) Topic: General game design considerations/process/terms*

Code when the therapist asked and/or the designer explained about general game design considerations (e.g. how storyline in general can serve as a hook to

get player back to play), process (e.g. prototyping, level design), and/or game design terms (e.g. pitch, play-through time).

*(c) Topic: Target player impairments/abilities*

Code when discussed about characteristics of the target player in the design scenario associated with her physical and/or cognitive impairments or abilities.

Do NOT code if they only read out aloud the patient impairments from the scenario. But DO code if they discussed about those impairments/abilities.

Do NOT code if they only talked about the therapy goals, but not the patient attributes.

*(d) Topic: Target player personality/taste/interest*

Code when discussed about characteristics of the target player in the design scenario associated with her personality, taste, and/or interest – e.g. the games she enjoyed playing.

Do NOT code if they only read out aloud the patient interests from the scenario. But DO code if they discussed about those interests/taste/personality.

*(e) Topic: Proposed game: high-level consideration*

Code when **exploring** high-level design considerations for the proposed game.

Examples include: need to provide adjustable parameters (time limit, difficulty, etc.), fast setup, provide positive feedback, mimicking real-life vs. fantasy, how to make the game different from other activities, intended/potential therapy value of the proposed game, etc.

DO NOT code when discussing how to realize those considerations (e.g. what parameters need to be adjusted) – code for other “Proposed game:” topics instead.

(f) *Topic: Proposed game: platform/controller*

Code when discussing the pros and cons of different game platforms or controllers, and/or discussing about which game platform/controller to use

(g) *Topic: Proposed game: fictional layer*

Code when discussing about designing the game’s fictional layers – deciding on the genre, theme, game goal (e.g. to collect dolls), aesthetics, and/or story of the game

(h) *Topic: Proposed game: core mechanics*

Code when discussing about designing the game’s core mechanics (i.e. the main activities players do **in the game**; e.g. marching, riding bicycle, etc.)

(i) *Topic: Proposed game: variations and elaborations*

Code when discussing about designing the game’s additional features and variations

Also code when elaborating a game design idea

E.g., various types of game elements (e.g. different types of dolls, challenges, etc.), different difficulty level, how the difficulty level progresses, how to incorporate the story in the game, etc.

(j) *Topic: Design patterns*

Code when the predominant activity was to discuss about how to use a game design pattern in their game or the meaning of a pattern

Also code when discussing about which game design pattern to look or to “save”

*(k) Topic: Other*

Code when the designer and/or the therapist are chatting about other topics.

### I.2.7 Using the tool

When the predominant activity is to use the GaPBIT tool, code the parts of the tool they are using and the following clicking events.

Note: Do not directly code on 7. Code on 7.a.1 to 7.b.12, then 7 is automatically calculated.

#### *I.2.7.1 Part of the tool*

*(a) Homepage*

Code when the predominant activity (in the current 10-second time slice) of the designer or the therapist was to look at the homepage of the tool.

*(b) Efficacy patterns list*

Code when the predominant activity was to look at the efficacy patterns list of the tool.

*(c) Experience patterns list*

Code when the predominant activity was to look at the experience patterns list of the tool.

(d) *My saved patterns*

Code when the predominant activity was to look at their saved patterns.

(e) *Pattern detailed info: definition/problem/solution*

Code when the predominant activity was to look at the pattern's definition, problem, and/or solution in the detailed info page. Do not code if they are clearly looking at the example games or the related patterns.

Please also note which pattern they are looking at in the "Pattern detailed info: which pattern" cell.

(f) *Pattern detailed info: example games*

Code when the predominant activity was to look at the pattern's example games in the detailed info page.

(g) *Pattern detailed info: related patterns*

Code when the predominant activity was to look at the pattern's related patterns in the detailed info page.

*1.2.7.2 Clicking events*

(a) *Event: Saved a pattern*

Code when a participant clicks "Add to saved patterns" button

(b) *Event: Clicked a related pattern*

Code when a participant clicks on a related pattern



## BIBLIOGRAPHY

- [1] About Brain Injury: <http://www.biausa.org/about-brain-injury.htm>.  
Accessed: 2015-03-24.
- [2] Admiraal, W., Huizenga, J., Akkerman, S. and Dam, G. Ten 2011. The concept of flow in collaborative game-based learning. *Computers in Human Behavior*. 27, 3 (May 2011), 1185–1194.
- [3] Alankus, G., Lazar, A., May, M. and Kelleher, C. 2010. Towards customizable games for stroke rehabilitation. *Proceedings of the 28th international conference on Human factors in computing systems CHI '10* (New York, NY, USA, 2010), 2113–2122.
- [4] Alexander, C. 1979. *The Timeless Way of Building*.
- [5] Alexander, C., Ishikawa, S. and Silverstein, M. 1977. *A Pattern Language: Towns, Buildings, Construction*.
- [6] Almeida, M.S.O. and Silva, F.S.C. 2013. Requirements for game design tools: A Systematic Survey. *Proceedings of SBGames 2013* (2013), 277–284.

- [7] Annema, J.-H., Verstraete, M., Vanden Abeele, V., Desmet, S. and Geerts, D. 2010. Videogames in therapy: a therapist's perspective. *Proceedings of the 3rd International Conference on Fun and Games - Fun and Games '10* (New York, NY, USA, 2010), 94–98.
- [8] Annett, M., Anderson, F., Goertzen, D., Halton, J., Ranson, Q., Bischof, W.F. and Boulanger, P. 2009. Using a multi-touch tabletop for upper extremity motor rehabilitation. *Proceedings of the 21st Annual Conference of the Australian Computer-Human Interaction Special Interest Group on Design: Open 24/7 - OZCHI '09* (2009), 261–264.
- [9] Ashley, M.J. 2010. *Traumatic Brain Injury: Rehabilitation, Treatment, and Case Management*. CRC Press.
- [10] Assassin's creed unity review: Another stab: 2014.  
<http://www.ign.com/articles/2014/11/11/assassins-creed-unity-review>.  
Accessed: 2015-03-05.
- [11] Barendregt, W. and Bekker, M.M. 2006. Developing a coding scheme for detecting usability and fun problems in computer games for young children. *Behavior research methods*. 38, 3 (Aug. 2006), 382–389.
- [12] Barr, P., Noble, J. and Biddle, R. 2007. Video game values: Human-computer interaction and games. *Interacting with Computers*. 19, 2 (2007),

180–195.

- [13] Bateman, C.M. and Boon, R. 2006. *21st Century Game Design*. Charles River Media.
- [14] Becker, K. 2009. Video Game Pedagogy: Good Games = Good Pedagogy. *Games: Purpose and Potential in Education*. Springer US. 73–125.
- [15] Belchior, P., Marsiske, M., Sisco, S., Yam, A. and Mann, W. 2012. Older adults' engagement with a video game training program. *Activities, adaptation & aging*. 36, 4 (Dec. 2012), 269–279.
- [16] Bellotti, F., Berta, R., Gloria, a. De and Primavera, L. 2009. Enhancing the educational value of video games. *Computers in Entertainment*. 7, 2 (Jun. 2009), 1.
- [17] Betker, A.L., Desai, A., Nett, C., Kapadia, N. and Szturm, T. 2007. Game-based exercises for dynamic short-sitting balance rehabilitation of people with chronic spinal cord and traumatic brain injuries. *Physical therapy*. 87, 10 (2007), 1389–1398.
- [18] Bianchi-Berthouze, N., Kim, W. and Patel, D. 2007. Does body movement engage you more in digital game play? And Why? *Affective Computing and Intelligent Interaction*. 102–113.

- [19] Björk, S. and Holopainen, J. 2004. *Patterns in game design*. Charles River Media.
- [20] Bonsignore, E., Moulder, V., Neustaedter, C., Hansen, D., Kraus, K. and Druin, A. 2014. Design Tactics for Authentic Interactive Fiction: Insights from Alternate Reality Game Designers. *Proceedings of the 32nd annual ACM conference on Human factors in computing systems - CHI '14*. (2014), 947–950.
- [21] Borchers, J.O. 2001. A pattern approach to interaction design. *AI & Society*. 15, (2001), 359–376.
- [22] Bosch, F. Van Den, Ribbens, W. and Looy, J. Van 2011. Doing It Themselves! A Mixed-Method Study into the Motivations of Players to “Create” in the Context of Gaming. *Think Design Play: 5th International DiGRA Conference (DIGRA-2011)* (2011).
- [23] Broeren, J., Bjorkdahl, A., Claesson, L., Goude, D., Lundgren-Nilsson, A., Samuelsson, H., Blomstrand, C., Sunnerhagen, K.S. and Rydmark, M. 2008. Virtual rehabilitation after stroke. *Studies in health technology and informatics*. 136, (2008), 77–82.
- [24] Brown, E. and Cairns, P. 2004. A grounded investigation of game immersion. *Extended abstracts of the 2004 conference on Human factors*

*and computing systems - CHI '04 (2004), 1297–1330.*

- [25] Brown, S.L. and Vaughan, C.C. 2009. *Play: How it shapes the brain, opens the imagination, and invigorates the soul.* Avery Trade.
- [26] Bruckman, A. 1999. Can Educational Be Fun? *Game Developer Conference (1999), 75–79.*
- [27] Buday, R. 2015. Games for Health: An Opinion. *Games for Health Journal.* 4, 1 (Feb. 2015), 38–42.
- [28] Buday, R., Baranowski, T. and Thompson, D. 2012. Fun and Games and Boredom. *Games for Health Journal.* 1, 4 (2012), 257–261.
- [29] Burke, J.W., McNeill, M., Charles, D., Morrow, P., Crosbie, J. and McDonough, S. 2009. Serious Games for Upper Limb Rehabilitation Following Stroke. *2009 Conference in Games and Virtual Worlds for Serious Applications (Mar. 2009), 103–110.*
- [30] Burke, J.W., McNeill, M.D.J., Charles, D.K., Morrow, P.J., Crosbie, J.H. and McDonough, S.M. 2010. Designing engaging, playable games for rehabilitation. *Proceedings of the 8th International Conference Series On Disability, Virtual Reality and Associated Technologies (ICDVRAT) (2010), 195–201.*

- [31] Burke, J.W., McNeill, M.D.J., Charles, D.K., Morrow, P.J., Crosbie, J.H. and McDonough, S.M. 2009. Optimising engagement for stroke rehabilitation using serious games. *The Visual Computer*. 25, 12 (Dec. 2009), 1085–1099.
- [32] Burke, J.W., Morrow, P.J., McNeill, M.D.J., McDonough, S.M. and Charles, D.K. 2008. Vision based games for upper-limb stroke rehabilitation. *Proceedings - IMVIP 2008, 2008 International Machine Vision and Image Processing Conference (2008)*, 159–164.
- [33] Buschmann, F., Meunier, R., Rohnert, H., Sommerlad, P. and Stal, M. 1996. *Pattern-Oriented Software Architecture, Volume 1: A System of Patterns*. Wiley, John & Sons.
- [34] Caillois, R. 1961. *Man, play and games*. University of Illinois Press.
- [35] Charmaz, K. 2014. *Constructing Grounded Theory*. SAGE Publications Ltd.
- [36] Chen, J. 2007. Flow in games (and everything else). *Communications of the ACM*. 50, 4 (Apr. 2007), 31.
- [37] Cheng, J. and Putnam, C. 2015. Therapeutic Gaming in Context: Observing Game Use for Brain Injury Rehabilitation. *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing*

*Systems - CHI EA '15* (2015), 1169–1174.

- [38] Cheng, J., Putnam, C. and Guo, J. 2016. “Always a Tall Order”: Values and Practices of Professional Game Designers of Serious Games for Health. *Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play - CHI PLAY '16* (New York, New York, USA, 2016), 217–228.
- [39] Cheng, J., Putnam, C. and Rusch, D.C. 2015. Towards Efficacy-Centered Game Design Patterns For Brain Injury Rehabilitation: A Data-Driven Approach. *Proceedings of the 17th International ACM SIGACCESS Conference on Computers & Accessibility* (2015), 291–299.
- [40] Cognitive problems after traumatic brain injury:  
<http://www.msktc.org/tbi/factsheets/Cognitive-Problems-After-Traumatic-Brain-Injury>. Accessed: 2015-03-24.
- [41] Colombo, R., Pisano, F., Mazzone, A., Delconte, C., Micera, S., Carrozza, M.C., Dario, P. and Minuco, G. 2007. Design strategies to improve patient motivation during robot-aided rehabilitation. *Journal of neuroengineering and rehabilitation*. 4, 3 (2007), 1–12.
- [42] Colwell, J. 2007. Needs met through computer game play among adolescents. *Personality and Individual Differences*. 43, 8 (Dec. 2007),

2072–2082.

- [43] Connor, B.B. and Standen, P.J. 2012. So much technology, so little time: factors affecting use of computer- based brain training games for cognitive rehabilitation following stroke. *Proc. 9th Intl Conf. on Disability, Virtual Reality and Associated Technologies* (2012), 53–59.
- [44] Cowley, B., Charles, D., Black, M. and Hickey, R. 2008. Toward an understanding of flow in video games. *Computers in Entertainment*. 6, 2 (2008), 1–27.
- [45] Crosbie, J.H., Lennon, S., McNeill, M.D.J. and McDonough, S.M. 2006. Virtual reality in the rehabilitation of the upper limb after stroke: the user’s perspective. *Cyberpsychology & behavior : the impact of the Internet, multimedia and virtual reality on behavior and society*. 9, 2 (2006), 137–141.
- [46] Csikszentmihalyi, M. 1997. *Finding flow: The psychology of engagement with everyday life*. BasicBooks.
- [47] Csikszentmihalyi, M. 1990. *Flow: The psychology of optimal experience*. Harper & Row.
- [48] Davis, J., Steury, K. and Pagulayan, R. 2005. A survey method for assessing perceptions of a game: The consumer playtest in game design.



*Game Studies*. (2005).

- [49] Dearden, A. and Finlay, J. 2006. Pattern languages in HCI : a critical review. *Human-Computer interaction*. 21, January 2015 (2006), 49–102.
- [50] Deci, E.L. and Ryan, R.M. 2010. Self Determination Theory. *Handbook of Theories of Social Psychology*. 416–437.
- [51] Definitions of ABI and TBI:  
<http://www.braininjurynetwork.org/thesurvivorsviewpoint/definitionofabiandtbi.html>. Accessed: 2015-03-24.
- [52] Denis, G. and Jouvelot, P. 2005. Motivation-driven educational game design: applying best practices to music education. *Proceedings of the 2005 ACM SIGCHI International Conference on Advances in computer entertainment technology - ACE '05* (New York, New York, USA, 2005), 462–465.
- [53] Desurvire, H., Caplan, M. and Toth, J.A. 2004. Using heuristics to evaluate the playability of games. *CHI'04 extended abstracts* (2004), 1509–1512.
- [54] Deterding, S. 2011. Situated motivational affordances of game elements : A conceptual model. *Gamification: Using Game Design Elements in Non-Gaming Contexts, a workshop at CHI '11* (2011).

- [55] Deutsch, J.E., Brettler, A., Smith, C., Welsh, J., John, R., Guarrera-Bowlby, P. and Kafri, M. 2012. Nintendo Wii Sports and Wii Fit Game Analysis, Validation, and Application to Stroke Rehabilitation. *Topics in Stroke Rehabilitation*. 18, 6 (2012), 701–719.
- [56] Deutsch, J.E., Robbins, D., Morrison, J. and Guarrera Bowlby, P. 2009. Wii-based compared to standard of care balance and mobility rehabilitation for two individuals post-stroke. *2009 Virtual Rehabilitation International Conference* (Jun. 2009), 117–120.
- [57] Diaz-Orueta, U., Facal, D., Nap, H.H. and Ranga, M.-M. 2012. What Is the Key for Older People to Show Interest in Playing Digital Learning Games? Initial Qualitative Findings from the LEAGE Project on a Multicultural European Sample. *Games for Health Journal*. 1, 2 (Apr. 2012), 115–123.
- [58] Dormann, C., Whitson, J.R. and Neuvians, M. 2013. Once More With Feeling: Game Design Patterns for Learning in the Affective Domain. *Games and Culture*. 8, 4 (Jul. 2013), 215–237.
- [59] Douglas, Y. and Hargadon, A. 2000. The pleasure principle: Immersion, Engagement, Flow. *Proceedings of the eleventh ACM on Hypertext and hypermedia - HYPERTEXT '00* (New York, New York, USA, 2000), 153–160.

- [60] Drachen, A., Canossa, A., Rau, J. and Sørensen, M. 2013. Gameplay Metrics in Game User Research: Examples from the Trenches. *Game Analytics: Maximizing the Value of Player Data*. M. Seif El-Nasr, A. Drachen, and A. Canossa, eds. Springer London. 285–319.
- [61] Dyck, J., Pinelle, D., Brown, B. and Gutwin, C. 2003. Learning from games: HCI design innovations in entertainment software. *Proceedings of Graphics Interface (2003)*, 237–246.
- [62] Educational Game Design Pattern Candidates: 2009. .
- [63] Egglestone, S., Axelrod, L., Nind, T., Turk, R., Wilkinson, A., Burridge, J., Fitzpatrick, G., Mawson, S., Robertson, Z., Hughes, A.M., Ng, K.H.N.K.H., Pearson, W., Shublaq, N., Probert-Smith, P., Ricketts, I. and Rodden, T. 2009. A design framework for a home-based stroke rehabilitation system: Identifying the key components. *3rd International Conference on Pervasive Computing Technologies for Healthcare (2009)*, 1–8.
- [64] Elaklouk, A.M. and Zin, N.A.M. 2012. Requirements for Game Based Cognitive Intervention System for Acquired Brain Injury. *GSTF Journal on Computing*. 2, 3 (2012), 25–31.
- [65] Entertainment Software Association 2016. Essential Facts About the

Computer and Video Game Industry.

- [66] Ermi, L. and Mäyrä, F. 2005. Fundamental Components of the Gameplay Experience: Analysing Immersion. *Proceedings of the DiGRA conference Changing views: worlds in play* (2005), 15–27.
- [67] Federoff, M.A. 2002. *Heuristics and usability guidelines for the creation and evaluation of fun in video games*. Indiana University.
- [68] Flores, E., Tobon, G., Cavallaro, E., Cavallaro, F.I., Perry, J.C. and Keller, T. 2008. Improving patient motivation in game development for motor deficit rehabilitation. *Proceedings of the 2008 International Conference in Advances in Computer Entertainment Technology - ACE '08* (New York, New York, USA, 2008), 381–384.
- [69] Flynn, S., Palma, P. and Bender, A. 2007. Feasibility of using the Sony PlayStation 2 gaming platform for an individual poststroke: a case report. *Journal of neurologic physical therapy : JNPT*. 31, 4 (Dec. 2007), 180–189.
- [70] Fu, F.-L., Su, R.-C. and Yu, S.-C. 2009. EGameFlow: A scale to measure learners' enjoyment of e-learning games. *Computers & Education*. 52, 1 (Jan. 2009), 101–112.
- [71] Gamma, E., Helm, R., Johnson, R.E. and Vlissides, J. 1995. *Design*

*patterns: elements of reusable object-oriented software.*

- [72] Garrido, J. and Maset, I. 2013. Balance disorder rehabilitation through movement interaction. *PervasiveHealth '13 Proceedings of the 7th International Conference on Pervasive Computing Technologies for Healthcare* (2013), 319–322.
- [73] Gil-Gómez, J.-A., Lloréns, R., Alcañiz, M. and Colomer, C. 2011. Effectiveness of a Wii balance board-based system (eBaViR) for balance rehabilitation: a pilot randomized clinical trial in patients with acquired brain injury. *Journal of neuroengineering and rehabilitation*. 8, 30 (Jan. 2011), 1–9.
- [74] Gil-Gómez, J.A., Lozano, J.A., Alcañiz, M. and Pérez, S.A. 2009. Nintendo Wii balance board for balance disorders. *2009 Virtual Rehabilitation International Conference, VR 2009* (2009), 213.
- [75] Gillen, G. 2010. *Stroke Rehabilitation: A Function-Based Approach*. Mosby.
- [76] Giusti, R., Hullett, K. and Whitehead, J. 2012. Weapon design patterns in shooter games. *Proceedings of the First Workshop on Design Patterns in Games - DPG '12* (2012), 1–7.
- [77] Goodman, E., Stolterman, E. and Wakkary, R. 2011. Understanding

interaction design practices. *Proceedings of the 2011 annual conference on Human factors in computing systems - CHI '11* (New York, New York, USA, 2011), 1061.

- [78] Goude, D., Björk, S. and Rydmark, M. 2007. Game design in virtual reality systems for stroke rehabilitation. *Studies in Health Technology and Informatics*. 125, (2007), 146–148.
- [79] Gould, J.D. and Lewis, C. 1985. Designing for Usability : Key Principles and What Designers Think. *Communications of the ACM*. 28, 3 (1985), 300–311.
- [80] Hagen, U. 2011. Designing for player experience : How professional game developers communicate design visions. *Journal of Gaming and Virtual Worlds*. 3, 3 (2011), 259–275.
- [81] Hardy, J. and Scanlon, M. 2009. The Science Behind Lumosity (Commercial web page). *Lumos Labs*.
- [82] Hazan, E. 2013. Contextualizing Data. *Game Analytics: Maximizing the Value of Player Data*. M. Seif El-Nasr, A. Drachen, and A. Canossa, eds. Springer London. 477–496.
- [83] Holopainen, J. and Björk, S. 2008. Gameplay design patterns for motivation. *GAMES: Virtual Worlds and Reality*. 169–172.

- [84] Hoonhout, H.C.M. 2008. Let the Game Tester do the Talking: Think Aloud and Interviewing to Learn About the Game Experience. *Game Usability: Advice from the Experts for Advancing the Player Experience*. 65–77.
- [85] Huizinga, J. 1950. *Homo Ludens, a study of the play-element in culture*. Roy Publishers.
- [86] Hullett, K. 2013. Cause-Effect Relationships between Design Patterns and Designer Intent in FPS Levels. *Proceedings of the 2nd Workshop on Design Patterns in Games (DPG 2013)* (2013).
- [87] Hullett, K. and Whitehead, J. 2010. Design patterns in FPS levels. *Proceedings of the Fifth International Conference on the Foundations of Digital Games - FDG '10* (New York, New York, USA, 2010), 78–85.
- [88] Huynh-Kim-Bang, B., Wisdom, J. and Labat, J.-M. 2010. Design Patterns in Serious Games: A Blue Print for Combining Fun and Learning. *Project SE-SG*.
- [89] Iacovides, I., Aczel, J., Scanlon, E. and Woods, W. 2013. Making Sense of Game-Play: How Can We Examine Learning and Involvement? *Transactions of the Digital Games Research Association (ToDIGRA)*. 1, 1 (2013), 1–17.
- [90] Inal, Y. and Cagiltay, K. 2007. Flow experiences of children in an

- interactive social game environment. *British Journal of Educational Technology*. 38, 3 (May 2007), 455–464.
- [91] Isbister, K., Flanagan, M. and Hash, C. 2010. Designing games for learning: insights from conversations with designers. *Proceedings of the 28th international conference on Human factors in computing systems - CHI '10* (New York, New York, USA, 2010), 2041–2044.
- [92] Isbister, K. and Mueller, F. “Floyd” 2015. Guidelines for the Design of Movement-Based Games and Their Relevance to HCI. *Human–Computer Interaction*. 30, 3–4 (May 2015), 366–399.
- [93] Jansz, J., Avis, C. and Vosmeer, M. 2010. Playing The Sims2: an exploration of gender differences in players’ motivations and patterns of play. *New Media & Society*. 12, 2 (Jan. 2010), 235–251.
- [94] Jegers, K. 2007. Pervasive Game Flow : Understanding Player Enjoyment in Pervasive Gaming. *Computers in Entertainment*. 5, 1 (2007), 1–11.
- [95] Jennett, C., Cox, A.L., Cairns, P., Dhoparee, S., Epps, A., Tijs, T. and Walton, A. 2008. Measuring and defining the experience of immersion in games. *International Journal of Human-Computer Studies*. 66, 9 (Sep. 2008), 641–661.
- [96] Jørgensen, A.H. 2004. Marrying HCI/Usability and computer games: a



preliminary look. *Proceedings of the third Nordic conference on Human-computer interaction* (2004), 393–396.

- [97] Jørgensen, K. 2011. Players as Coresearchers: Expert Player Perspective as an Aid to Understanding Games. *Simulation & Gaming*. 43, 3 (Sep. 2011), 374–390.
- [98] Juul, J. 2005. *Half-Real: Video Games between Real Rules and Fictional Worlds*. MIT Press.
- [99] Kam, M. and Rudraraju, V. 2007. Mobile gaming with children in rural India: Contextual factors in the use of game design patterns. *Situated Play, Proceedings of DiGRA 2007 Conference* (2007).
- [100] Karakaya, B., Garcia, C., Rodriguez, D., Nityanandam, M., Labeikovsky, N. and Al Tamimi, T. 2009. Sketch-it-up! Demo. *Entertainment Computing–ICEC 2009* (2009), 313–314.
- [101] Keedwell, D. and Dénes, J. 2015. *Latin squares and their applications*. Elsevier2015.
- [102] Kelle, S., Klemke, R. and Specht, M. 2011. Design patterns for learning games. *International Journal of Technology Enhanced Learning*. 3, 6 (2011), 555–569.

- [103] Kelle, S., Klemke, R. and Specht, M. 2013. Effects of Game Design Patterns on Basic Life Support Training Content. *Journal of Educational Technology & Society*. 16, 1 (2013), 275–285.
- [104] Khaled, R. and Ingram, G. 2012. Tales from the front lines of a large-scale serious game project. *Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems - CHI '12* (New York, New York, USA, 2012), 69–78.
- [105] Kiili, K. 2007. Foundation for problem-based gaming. *British Journal of Educational Technology*. 38, 3 (May 2007), 394–404.
- [106] Kim, Y. and Ross, S.D. 2006. An exploration of motives in sport video gaming. *International Journal of Sports Marketing and Sponsorship*. 8, 1 (2006), 34–47.
- [107] Kobayashi, M. and Iloreta, J. 2013. Diary studies: A method for games user research “in the wild.” *CHI'13 Workshop – Games User Research: Practice, Methods, and Applications* (2013).
- [108] Koster, R. 2013. *A Theory of Fun for Game Design*. O'Reilly Media.
- [109] Kuittinen, J.M. 2008. *Computer-Aided Game Design*. University of Jyväskylä.

- [110] Laamarti, F., Eid, M. and El Saddik, A. 2014. An overview of serious games. *International Journal of Computer Games Technology*. 2014, (2014).
- [111] Landis, J.R. and Koch, G.G. 1977. The Measurement of Observer Agreement for Categorical Data. *Biometrics*. 33, 1 (Mar. 1977), 159.
- [112] Lange, B., Chang, C.-Y., Suma, E., Newman, B., Rizzo, A.S. and Bolas, M. 2011. Development and evaluation of low cost game-based balance rehabilitation tool using the Microsoft Kinect sensor. *Annual International Conference of the IEEE Engineering in Medicine and Biology Society* (Jan. 2011), 1831–1834.
- [113] Lange, B., Flynn, S. and Rizzo, A. 2009. Initial usability assessment of off-the-shelf video game consoles for clinical game-based motor rehabilitation. *Physical Therapy Reviews*. 14, 5 (Oct. 2009), 355–363.
- [114] Lemay, P. 2007. Developing a pattern language for flow experiences in video games. *DiGRA '07 - Proceedings of the 2007 DiGRA International Conference: Situated Play* (2007), 449–455.
- [115] Lewis, C., Wardrip-Fruin, N. and Whitehead, J. 2012. Motivational game design patterns of 'ville games. *Proceedings of the International Conference on the Foundations of Digital Games - FDG '12* (New York,

New York, USA, 2012), 172–179.

- [116] Lewis, C.F. 2013. *Motivational Design Patterns*.
- [117] Limperos, A.M., Schmierbach, M.G., Kegerise, A.D. and Dardis, F.E. 2011. Gaming across different consoles: exploring the influence of control scheme on game-player enjoyment. *Cyberpsychology, behavior and social networking*. 14, 6 (Jun. 2011), 345–350.
- [118] Lucas, K. and Sherry, J.L. 2004. Sex Differences in Video Game Play: A Communication-Based Explanation. *Communication Research*. 31, 5 (Oct. 2004), 499–523.
- [119] Al Mahmud, A., Mubin, O., Shahid, S. and Martens, J.-B. 2008. Designing and evaluating the tabletop game experience for senior citizens. *Proceedings of the 5th Nordic conference on Human-computer interaction building bridges - NordiCHI '08* (New York, New York, USA, 2008), 403–406.
- [120] Malone, T.W. 1981. Toward a theory of intrinsically motivating instruction. *Cognitive Science*. 5, 4 (Dec. 1981), 333–369.
- [121] Malone, T.W. 1980. What makes things fun to learn? Heuristics for designing instructional computer games. *Symposium on Small Systems* (New York, NY, USA, 1980), 162–169.

- [122] Malone, T.W. and Lepper, M.R. 1987. Making learning fun: A taxonomy of intrinsic motivations for learning. *Aptitude, learning, and instruction*. 3, 3 (1987), 223–253.
- [123] Mandryk, R. 2008. Physiological Measures for Game Evaluation. *Game Usability: Advice from the Experts for Advancing the Player Experience*. 207–235.
- [124] Manker, J. and Arvola, M. 2011. Prototyping in Game Design: Externalization and Internalization of Game Ideas. *BCS-HCI '11 Proceedings of the 25th BCS Conference on Human-Computer Interaction* (2011), 279–288.
- [125] Marne, B., Wisdom, J., Huynh-kim-bang, B., Paris, J. and Labat, J. 2012. A Design Pattern Library for Mutual Understanding and Cooperation in Serious Game Design. *Intelligent Tutoring Systems*. Springer. 135–140.
- [126] McClanachan, N.J., Gesch, J., Wuthapanich, N., Fleming, J. and Kuys, S.S. 2013. Feasibility of gaming console exercise and its effect on endurance, gait and balance in people with an acquired brain injury. *Brain injury*. 27, 12 (Jan. 2013), 1402–8.
- [127] McGraw, K.O. and Wong, S.P. 1996. Forming inferences about some intraclass correlations coefficients. *Psychological Methods*. 1, 1 (1996),

30–46.

- [128] Mekler, E.D., Bopp, J.A., Tuch, A.N. and Opwis, K. 2014. A systematic review of quantitative studies on the enjoyment of digital entertainment games. *Proceedings of the 32nd annual ACM conference on Human factors in computing systems - CHI '14*. (2014), 927–936.
- [129] Mekler, E.D., Tuch, A.N., Martig, A.L. and Opwis, K. 2014. A diary study exploring game completion and player experience. *Proceedings of the first ACM SIGCHI annual symposium on Computer-human interaction in play - CHI PLAY '14* (2014), 433–434.
- [130] Mueller, F.F. and Isbister, K. 2014. Movement-Based Game Guidelines. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems - CHI '14* (2014), 2191–2200.
- [131] Nacke, L. and Lindley, C.A. 2008. Flow and immersion in first-person shooters: Measuring the player's gameplay experience. *Proceedings of the 2008 Conference on Future Play Research, Play, Share - Future Play '08* (New York, New York, USA, 2008), 81–88.
- [132] Nacke, L.E. 2013. An Introduction to Physiological Player Metrics for Evaluating Games. *Game Analytics: Maximizing the Value of Player Data*. M. Seif El-Nasr, A. Drachen, and A. Canossa, eds. Springer London. 585–

619.

- [133] Nakamura, J. and Csikszentmihalyi, M. 2002. The Concept of Flow. *Handbook of positive psychology*. C.R. Snyder and S.J. Lopez, eds. Oxford University Press. 89–105.
- [134] Neil, K. 2012. Game design tools: Time to evaluate. *Proceedings of 2012 DiGRA Nordic* (2012).
- [135] Nelson, M.J. and Mateas, M. 2009. A requirements analysis for videogame design support tools. *Proceedings of the 4th International Conference on Foundations of Digital Games - FDG '09* (2009), 137–144.
- [136] Nicholson, S. 2012. A User-Centered Theoretical Framework for Meaningful Gamification A Brief Introduction to Gamification Organismic Integration Theory Situational Relevance and Situated Motivational Affordance. *Games+ Learning+ Society* (2012), 1–7.
- [137] Nigel Cross 2006. *Designerly Ways of Knowing*. Springer-Verlag.
- [138] Osorio, G., Moffat, D.C. and Sykes, J. 2012. Exergaming, Exercise, and Gaming: Sharing Motivations. *Games for Health Journal*. 1, 3 (Jun. 2012), 205–210.
- [139] Paavola, J.M., Oliver, K.E. and Ustinova, K.I. 2013. Use of X-box Kinect

- Gaming Console for Rehabilitation of an Individual with Traumatic Brain Injury: A Case Report. *Journal of Novel Physiotherapies*. 3, 1 (2013), 1–6.
- [140] Pagulayan, R.J., Keeker, K., Wixon, D., Romero, R.L. and Fuller, T. 2003. User-centered Design in Games. *The human-computer interaction handbook: fundamentals, evolving technologies and emerging applications*. 883–906.
- [141] Papacharissi, Z. 2008. Uses and gratifications. *An Integrated Approach to Communication Theory and Research*. M.B. Salwen and D.W. Stacks, eds. Lawrence Erlbaum. 137–152.
- [142] Pausch, R., Gold, R., Skelly, T. and Thiel, D. 1994. What HCI designers can learn from video game designers. *Conference companion on Human factors in computing systems - CHI '94* (New York, New York, USA, 1994), 177–178.
- [143] Peng, W., Lin, J.-H., Pfeiffer, K. a. and Winn, B. 2012. Need Satisfaction Supportive Game Features as Motivational Determinants: An Experimental Study of a Self-Determination Theory Guided Exergame. *Media Psychology*. 15, 2 (May 2012), 175–196.
- [144] Petri, H.L. and Govern, J.M. 2003. *Motivation: theory, research and application*. Cengage Learnings.



- [145] Poels, K., de Kort, Y. and Ijsselsteijn, W. 2007. "It is always a lot of fun!": exploring dimensions of digital game experience using focus group methodology. *Proceedings of the 2007 conference on Future Play - Future Play '07* (New York, New York, USA, 2007), 83–89.
- [146] Projections of mortality and causes of death: 2015.  
[http://www.who.int/healthinfo/global\\_burden\\_disease/projections/en/](http://www.who.int/healthinfo/global_burden_disease/projections/en/).  
Accessed: 2016-06-06.
- [147] Przybylski, A.K., Rigby, C.S. and Ryan, R.M. 2010. A motivational model of video game engagement. *Review of General Psychology*. 14, 2 (2010), 154–166.
- [148] Przybylski, A.K., Ryan, R.M. and Rigby, C.S. 2009. The motivating role of violence in video games. *Personality & social psychology bulletin*. 35, 2 (Mar. 2009), 243–59.
- [149] Przybylski, A.K., Weinstein, N., Ryan, R.M. and Rigby, C.S. 2009. Having to versus wanting to play: background and consequences of harmonious versus obsessive engagement in video games. *Cyberpsychology & behavior : the impact of the Internet, multimedia and virtual reality on behavior and society*. 12, 5 (Oct. 2009), 485–92.
- [150] Putnam, C. and Cheng, J. 2014. Therapist-centered requirements: A multi-

method approach of requirement gathering to support rehabilitation gaming. *Proceedings of the IEEE 22nd International Requirements Engineering Conference (RE 2014)* (2014), 13–22.

- [151] Putnam, C., Cheng, J., Lin, F., Yalla, S. and Wu, S. 2016. “Choose a Game”: Creation and Evaluation of a Prototype Tool to Support Therapists in Brain Injury Rehabilitation. *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems - CHI '16* (2016), 2038–2049.
- [152] Putnam, C., Cheng, J. and Seymour, G. 2014. Therapist Perspectives: Wii Active Videogames Use in Inpatient Settings with People Who Have Had a Brain Injury. *Games for Health Journal*. 3, 6 (2014), 366–370.
- [153] Putnam, C., Reiner, A., Ryou, E., Caputo, M., Cheng, J., Allen, M. and Singamaneni, R. 2016. Human-Centered Design in Practice: Roles, Definitions, and Communication. *Journal of Technical Writing and Communication*. 46, 4 (Jun. 2016), 446–470.
- [154] Quick Facts About Brain Injury: <http://www.biausa.org/bia-media-center.htm>. Accessed: 2015-03-17.
- [155] Rand, D., Kizony, R. and Weiss, P.L. 2004. Virtual reality rehabilitation for all : Vivid GX versus Sony PlayStation II EyeToy. *Proceedings of the 5th International Conference Series On Disability, Virtual Reality and*

*Associated Technologies (ICDVRAT)* (2004), 87–94.

- [156] Rector, K., Bennett, C.L. and Kientz, J.A. 2013. Eyes-Free Yoga: An Exergame Using Depth Cameras for Blind & Low Vision Exercise. *Proceedings of the 15th International ACM SIGACCESS Conference on Computers and Accessibility - ASSETS '13* (New York, New York, USA, 2013), 1–8.
- [157] Ribbens, W. and Poels, Y. 2009. Researching player experiences through the use of different qualitative methods. *Proceedings of DiGRA 2009 Conference: Breaking New Ground: Innovation in Games, Play, Practice and Theory* (2009), 1–10.
- [158] Rosson, M.B., Maass, S. and Kellogg, W. a. 1987. Designing for designers: an analysis of design practice in the real world. *Proceedings of the SIGCHI/GI conference on Human factors in computing systems and graphics interface - CHI '87* (New York, New York, USA, May 1987), 137–142.
- [159] Ryan, R.M. and Deci, E.L. 2000. Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemporary educational psychology*. 25, 1 (Jan. 2000), 54–67.
- [160] Ryan, R.M. and Deci, E.L. 2000. Self-determination theory and the

- facilitation of intrinsic motivation, social development, and well-being. *The American psychologist*. 55, 1 (Jan. 2000), 68–78.
- [161] Ryan, R.M., Rigby, C.S. and Przybylski, A. 2006. The Motivational Pull of Video Games: A Self-Determination Theory Approach. *Motivation and Emotion*. 30, 4 (Nov. 2006), 344–360.
- [162] Ryan, W. and Charsky, D. 2013. Integrating Serious Content into Serious Games. *Foundations of Digital Games* (2013), 330–337.
- [163] Ryan, W., Street, E. and Siegel, M.A. 2009. Evaluating Interactive Entertainment using Breakdown: Understanding Embodied Learning in Video Games. *Breaking New Ground: Innovation in Games, Play, Practice and Theory. Proceedings of DiGRA 2009* (2009).
- [164] Saldaña, J. 2009. *The coding manual for qualitative researchers*. Sage.
- [165] Salen, K. and Zimmerman, E. 2004. *Rules of play: game design fundamentals*. MIT Press.
- [166] Schaffer, N. 2007. Heuristics for usability in games. *White Paper*.
- [167] Schell, J. 2008. *The Art of Game Design: A book of lenses*. Morgan Kaufmann.
- [168] Schön, D.A. 1984. *The Reflective Practitioner: How Professionals Think in*

*Action*. Basic Books.

- [169] Schönauer, C., Pintaric, T. and Kaufmann, H. 2011. Full Body Interaction for Serious Games in Motor Rehabilitation. *Proceedings of the 2nd Augmented Human International Conference* (2011).
- [170] Sherry, J.L., Lucas, K., Greenberg, B.S. and Lachlan, K. 2006. Video game uses and gratifications as predictors of use and game preference. *Playing computer games: Motives, responses, and consequences*. Lawrence Erlbaum. 213–224.
- [171] Shim, K.J., Hsu, K.-W. and Srivastava, J. 2011. An Exploratory Study of Player Performance, Motivation, and Enjoyment in Massively Multiplayer Online Role-Playing Games. *2011 IEEE Third Int'l Conference on Privacy, Security, Risk and Trust and 2011 IEEE Third Int'l Conference on Social Computing* (Oct. 2011), 135–140.
- [172] Shrout, P.E. and Fleiss, J.L. 1979. Intraclass correlations: Uses in assessing rater reliability. *Psychological Bulletin*. 86, 2 (1979), 420–428.
- [173] Silver, J.M., McAllister, T.W. and Yudofsky, S.C. 2011. *Textbook of traumatic brain injury*. American Psychiatric Publishing, Inc.
- [174] Sinclair, J., Hingston, P. and Masek, M. 2009. Exergame development using the dual flow model. *Proceedings of the Sixth Australasian*

*Conference on Interactive Entertainment - IE '09* (New York, New York, USA, 2009), 1–7.

- [175] Smith, G., Anderson, R., Kopleck, B., Lindblad, Z., Scott, L., Wardell, A., Whitehead, J. and Mateas, M. 2011. Situating Quests: Design Patterns for Quest and Level Design in Role-Playing Games. *Proceedings of the 4th international conference on Interactive Digital Storytelling (ICIDS'11)* (2011), 326–329.
- [176] Sørum, H. 2015. Do We Really Emphasize the Users That Much? Explorative Interviews With Interaction Designers. *Norsk konferanse for organisasjoners bruk av IT*. 23, 1 (2015).
- [177] Sotamaa, O., Ermi, L. and Jäppinen, A. 2005. The role of players in game design: A methodological perspective. ... *the 6th DAC Conference*. (2005), 34–42.
- [178] Stolterman, E., McAtee, J., Royer, D. and Thandapani, S. 2008. Designerly Tools. *Undisciplined! Proceedings of the Design Research Society Conference 2008* (Sheffield, UK, 2008).
- [179] Stolterman, E. and Pierce, J. 2012. Design Tools in Practice: Studying the Designer-Tool Relationship in Interaction Design. *Proceedings of the Designing Interactive Systems Conference on - DIS '12* (New York, New

York, USA, 2012), 25.

- [180] Suits, B. 1978. *The Grasshopper: Games, Life and Utopia*. University of Toronto Press.
- [181] Sweetser, P. and Wyeth, P. 2005. GameFlow: a model for evaluating player enjoyment in games. *Computers in Entertainment (CIE) - Theoretical and Practical Computer Applications in Entertainment*. 3, 3 (Jul. 2005), 1–24.
- [182] The Case For Game Design Patterns: 2002.  
[http://www.gamasutra.com/view/feature/132649/the\\_case\\_for\\_game\\_design\\_patterns.php?print=1](http://www.gamasutra.com/view/feature/132649/the_case_for_game_design_patterns.php?print=1).
- [183] The last of us review: Survival of the fittest: 2013.  
<http://www.ign.com/articles/2013/06/05/the-last-of-us-review>. Accessed: 2015-03-05.
- [184] Thin, a. G., Hansen, L. and McEachen, D. 2011. Flow Experience and Mood States While Playing Body Movement-Controlled Video Games. *Games and Culture*. 6, 5 (Mar. 2011), 414–428.
- [185] Thompson, D., Baranowski, T., Buday, R., Baranowski, J., Thompson, V., Jago, R. and Griffith, M.J. 2010. Serious Video Games for Health: How Behavioral Science Guided the Development of a Serious Video Game. *Simulation & gaming*. 41, 4 (Aug. 2010), 587–606.

- [186] Vasalou, A., Ingram, G. and Khaled, R. 2012. User-centered research in the early stages of a learning game. *Proceedings of the Designing Interactive Systems Conference on - DIS '12*. (2012), 116.
- [187] Weedon, B. 2013. Game Metrics Through Questionnaires. *Game Analytics: Maximizing the Value of Player Data*. M. Seif El-Nasr, A. Drachen, and A. Canossa, eds. Springer London. 515–537.
- [188] Weinstein, N., Przybylski, A.K. and Ryan, R.M. 2009. Can nature make us more caring? Effects of immersion in nature on intrinsic aspirations and generosity. *Personality and social psychology bulletin*. 35, 10 (2009), 1315–1329.
- [189] Weiss, M. and Mouratidis, H. 2008. Selecting security patterns that fulfill security requirements. *Proceedings of the 16th IEEE International Requirements Engineering Conference, RE'08* (2008), 169–172.
- [190] What do we mean when we call a game “immersive”? 2010.  
<http://www.theguardian.com/technology/gamesblog/2010/aug/10/games-science-of-immersion>. Accessed: 2015-03-05.
- [191] Why we play games: Four keys to more emotion without story: 2004. .
- [192] Yavuzer, G., Senel, a., Atay, M.B. and Stam, H.J. 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 (2008), 237–244.

- [193] Yim, J. and Graham, T.C.N. 2007. Using games to increase exercise motivation. *Proceedings of the 2007 conference on Future Play - Future Play '07*. (2007), 166–173.
- [194] Zain, N.H.M., Jaafar, A. and Razak, F.H.A. 2012. SGameFlow framework: How to experience enjoyment in Serious Game (SG) for Motor Impaired Users (MIU). *2012 International Conference on Computer & Information Science (ICCIS)*. (Jun. 2012), 1020–1024.
- [195] Zhang, X. and Wakkary, R. 2014. Understanding the role of designers' personal experiences in interaction design practice. *Proceedings of the 2014 conference on Designing interactive systems - DIS '14* (New York, New York, USA, 2014), 895–904.
- [196] Zickefoose, S., Hux, K., Brown, J. and Wulf, K. 2013. Let the games begin: a preliminary study using attention process training-3 and Lumosity™ brain games to remediate attention deficits following traumatic brain injury. *Brain injury : [BI]*. 27, 6 (2013), 707–16.