Looking through the Lens: Contextualizing and Operationalizing Design Recommendations for Rehabilitation Games for Young People

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Games for physical therapy can motivate patients, and HCI research has provided various recommendations for their design. However, such recommendations often remain at a high level: They are rarely reviewed with patients or appraised through application to game design and analysis. We address this gap by refining and operationalizing existing lessons for therapeutic games for young people. First, we report on semi-structured interviews with young people (aged 7–16) and parents, reviewing the lessons. Second, we operationalize them using an established collection of game design patterns to provide concrete guidance for game design and analysis. We critically appraise our approach through application to two games for physical therapy, *Liberi* and *Wii Fit*. Results show that high-level design implications can be made actionable using existing game design patterns, and we contribute a practical approach for the analysis and design of games for physical therapy.

CCS Concepts: • **Human-centered computing** → **User studies**; • **Software and its engineering** → **Interactive games**.

Additional Key Words and Phrases: Games, Motivation, Physical Therapy, Rehabilitation, Self-Determination Theory

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1 Introduction

Patient motivation is highly important as a precursor to treatment adherence in physical therapy, particularly for children and adolescents engaged in regular and long-term treatment [42]. Typically, therapists support patient motivation through individualized exercises and feedback [62, 77]. However, being grounded in human interaction, this support may not always come in the ideal form, potentially resulting in diminished motivation and withdrawal from treatment [42, 79, 89]. Due to their unique characteristics [83], video games are widely viewed as a promising way to

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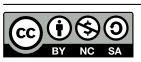

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support patient motivation [12, 60], leveraging best practices from game design to create engaging experiences. Here, Human-Computer Interaction (HCI) and games research have provided various design frameworks and recommendations, for example addressing the need for positive experiences among specific groups of players such as older adults [5], and challenges with respect to long-term player motivation [55]. More recently, Aufheimer et al. [7] provided an in-depth exploration of physical and occupational therapists' practice, and suggest that accounting for strategies from therapeutic practice in traditional settings may also provide valuable insights for the creation of games in this space. In particular, the authors show that therapists are experts at motivating patients, in some cases employing strategies that contradict common game design approaches (e.g., the avoidance of negative feedback [7, p. 12f.]). Aufheimer et al. [7] provide four recommendations for how the design of physical therapy games can be informed by therapists' practice, e.g., through adopting a more holistic perspective on adaptation or by viewing player performance through the lens of vulnerability.

However, when viewing these recommendations against Sas et al.'s [84] types of implications for design, it becomes apparent that they are high-level with little concrete instruction for designers, and that they have not been appraised from the perspective of patients. Here, Kuittinen and Holopainen [59] highlight the importance of designers' understanding of the design context, underscoring the need to address the experiences of young people participating in therapy in addition to that of therapists, while simultaneously needing to provide concrete guidance for the analysis and design of games for therapy. This challenge is relevant to recommendations for design on a broader level: Often, these represent a *contribution* (e.g., as articulated in the context of HCI conference contributions [1], and as observed in publications of the games research community [14, 54]). In other words, recommendations for design represent an end point of research, and hence, their applicability and actionability often remain unexplored.

In this paper, we build on Aufheimer et al.'s [7] key lessons for games for therapy for young people to address this research gap, raising two research questions:

(RQ1) How do young people participating in physical therapy perceive motivational strategies employed by therapists, and what context do these young people's perspectives add to the game design process?

(RQ2) How can high-level implications for design be operationalized into actionable guidance for the design and analysis of games for physical therapy?

We approached these RQs through a three-step process. We first address *(RQ1)* in Section 4 by assessing and refining Aufheimer et al.'s [7, p. 13] four key lessons to incorporate young people's perspectives. We carried out semi-structured interviews with nine young persons (aged 7—16) engaged in physical therapy and eight parents[1] of these young people, focusing on perspectives towards motivational strategies commonly applied by therapists. We found that young people's and parents' experiences largely aligned with therapists' views; e.g., young people rarely experienced failure in physical therapy and if they did, the feedback they received from their therapist managed the negative experience. The key lessons resulting from this step are presented in Section 4.5.

In Section 5, we address *(RQ2)* by using the key lessons to evaluate a set of patterns from Bjork and Holopainen's [10] *Patterns in Game Design*. In this evaluation, we specifically focus on games for physical therapy. This appraisal shows that traditional design patterns are applicable to rehabilitation games, but require considerable nuance in their application. This highlights the need to balance the motivational perspective of the key lessons with game design practice.

[1]We required the participating adults to be legal guardians of the young people participating in the study and did not collect details on their relationship. For readability, we refer to the participating adults as parents.

Finally, in Section 6, we show how the key lessons act as a lens for adapting game design patterns for rehabilitation gaming. We illustrate this approach through the analysis of two existing games used in physical therapy, *Liberi* [37] and *Wii Fit* [23]. We use these examples to investigate how well game mechanics and elements align with the key lessons and critically reflect on their implementation. Through examples of the modification of design patterns for the rehabilitation context, we show how we intend that designers use our key lessons: as a lens through which concrete design patterns can be applied and modified. Second, we find that despite both games having been shown to be beneficial to therapeutic practice and enjoyed by participants [50, 96], there is potential for improvements to designs by increasing alignment with the key lessons.

Our work makes three key contributions: (1) Assessment of Aufheimer et al.'s [7] key lessons from the perspective of young people participating in physical therapy. Adding this perspective makes the lessons more reliably applicable by game designers. (2) Examples of operationalizing the key lessons as lenses for reflection on game design patterns and analysis of existing rehabilitative gaming systems. (3) A critical exploration of best practices in the HCI games research community when working with recommendations for design.

2 Positionality

When engaging with our research, it is important to understand the backgrounds represented within the research team. The authors of this work are trained in computer science, media design, and the social sciences. Collectively, the members of the research team have previously conducted theoretical work on the design and development of games for physical therapy and accessible games, and have designed and developed such systems. Outside their work context, the authors have personal experience in attending long-term physical therapy and parenting children, some of whom have attended long-term physical therapy.

3 Background

We first summarize literature on games for physical therapy and rehabilitation. We then provide an overview of structured approaches to game design and reflect on how the research community currently provides design guidance in this space.

3.1 Games for Physical Therapy and Rehabilitation

An early review of video games for health by Kato [53] has shown the potential of games to improve physical therapy outcomes through increased motivation and engagement in both custom-made and commercially available systems. This notion of video games seemingly being an ideal tool to support physical therapy is further reinforced through research focusing on their inherent motivational pull [83], and potential to increase adherence to physical therapy by engaging patients [60], while providing an overall enjoyable experience, positive functional outcomes, and low associated costs [12, 44, 93]. There are a number of commercially available games that have been successfully applied in therapy, for example, *Wii Fit* [23] and *Wii Sports* [22]. While designed for entertainment, prior work has shown that the application of these gaming systems in the context of physical therapy and rehabilitation yields functional improvements [4, 50, 63, 96], and is enjoyed by people of various ages [4, 50, 65, 105, 106].

Some systems also lie at the intersection of scientific research and commercial development, and target game-based physical therapy for young people specifically: The *reFit Gamo* system [76] has been commercially developed in close collaboration with various clinical stakeholders. In a pilot study testing different systems with young people [57], *reFit Gamo* was positively evaluated regarding enjoyment and functional outcomes, although the authors highlight therapists' intervention as essential to young people's motivation and emphasize the individuality of therapeutic requirements.

Similarly, Hernandez et al.'s [37] *Liberi* exergames were developed in an iterative, participatory process in cooperation with clinical partners, and are specifically targeted towards the needs of young people with neurodevelopmental disorders. The games have since been trialed with various groups of young people [33, 52, 58, 87], and were positively evaluated regarding overall player experience [37, 87] and functional improvements [58]. *Bootle Blast* is a commercial rehabilitation game for young people with hemiplegia and has been shown to provide improvement to upper limb motor skills in a home environment where access to physiotherapy is limited [15].

Likewise, HCI games research has contributed case studies: Alankus et al. [5] worked with therapists to iteratively develop a set of mini-games to encourage upper-body movement specifically for stroke rehabilitation. Based on user tests, the authors provide a set of high-level lessons learned regarding usability, functional requirements, and overall player experience. In more recent work, Tamayo-Serrano et al. [95] developed a therapeutic system comprising six mini-games. During design, they either chose a game for its apparent recreational value and adapted it to meet therapeutic goals or abstracted functional exercises through a game. The system and both design approaches were positively evaluated. Focusing on a similar target group, Smeddinck et al. [90] investigated a set of mini-games targeting upper-body mobility in older adults. The mini-games were developed in a player-centered, iterative process, and were positively evaluated regarding functional outcomes and measures of player motivation. Zsolczay et al. [108] developed a game incorporating gestures used in hand rehabilitation exercises as an input mechanism to navigate the game world. The game targets all ages, and was developed in an iterative process, focusing mainly on technical functionality (i.e., gesture recognition and usability). It was positively evaluated regarding engagement.

Interestingly, what unites all these academic case studies is their brief (or undocumented) engagement with structured approaches to game design in general, and game design for physical therapy: While the developed systems and prototypes received generally positive evaluation scores and feedback, the lack of a unified, systematic approach makes it difficult to generate and generalize actionable implications for the design of future games.

3.2 Structured Approaches to Game Design

Here, we provide an overview of structured approaches such as frameworks or patterns for game design, and game design considerations specifically for the context of physical therapy and rehabilitation.

3.2.1 Models and Frameworks. The literature offers different ways of approaching game design. High-level descriptions of games and their elements—often presented in the form of models or frameworks—are found alongside more detailed and practical recommendations for their implementation. For example, Hunicke et al. [45] contribute the MDA Framework, which defines the elements of games as mechanics (e.g., rules and basic actions), dynamics (i.e., the mapping of mechanics onto player input and combination into more complex actions), and aesthetics (i.e., the emotions a game evokes in players). Similarly, Fullerton [28] describes games as a system comprised of the interaction between players, objectives, procedures (i.e., actions a player can take), rules, resources (i.e., assets used to accomplish a (sub-)goal), conflict, boundaries (i.e., what separates the game from reality), and outcome, providing a comprehensive guiding work of reference on the process of play-centric game design. Adams and Dormans [2], on the other hand, focus on mechanics defining relationships between game elements (e.g., mechanics that control progress by blocking / unlocking paths ahead) and describe a set of abstract design patterns (e.g., engine patterns that describe forms of resource production) alongside examples of how they may be implemented and relations between patterns. Adopting a different perspective, Schell [86] argues against rigorous definitions

and proposes a set of lenses—different perspectives one may take on during the design process—to guide the process of creation through observation and reflection.

There have been attempts to create higher-level frameworks in HCI games research which aim to formalize specific aspects of game design: Hicks et al. [39] conducted work elaborating the effects of Juicy Design (i.e., redundant audiovisual feedback) on player experience, while a systematic literature review by Gonçalves et al. [32] shows the wealth of social dimensions in digital games. Similarly, based on a systematic analysis of cooperative video games, Pais et al. [69] have constructed a framework structuring the design of game elements that support cooperation.

While universal models and literature on game design condense and communicate a wealth of generalizable knowledge, they remain abstract, offering little actionable guidance on how to achieve specific goals in the design process, especially for inexperienced or non-professional game designers, or in specific contexts such as physical therapy. Similarly, frameworks, albeit often more narrowly focused, typically offer only a high-level understanding of the specific topic they address, and are not easily applicable to the context of physical therapy.

3.2.2 Game Design Patterns. Game design pattern collections typically take a very direct, practically applicable approach. Bjork and Holopainen [10] define 296 general game design patterns for their initial collection which continues to grow in an online collection and currently spans 623 patterns[2]. The patterns focus on elements of games at various levels of abstraction, such as deathly traps (i.e., hidden game elements that lead to the player character's demise) or cooperation (i.e., multiple players cooperating to reach the (sub-)goals of the game). A similar community-driven online collection of game design patterns[3] stems from Barney's [9] *Pattern Language for Game Design*. The work offers a comprehensive introduction to pattern theory and the use of patterns in game design alongside exercises and examples to teach and guide designers in defining their own patterns and unifying vocabulary to interconnect the self-defined patterns.

A more context-driven approach can be observed in Wetzel et al.'s [102] collection of mixed reality game design patterns: While some of the patterns are commonly observed in game design (e.g., collaboration), their focus within this set is targeted specifically towards mixed reality games. Another context-driven approach has been taken by Power et al. [48, 73] on their collection of accessible player experience patterns, taking into account technical implications as well as meta-patterns (e.g., giving players the option to remap controls or bypass parts of the game), aligning with guidelines such as the Game Accessibility Guidelines [8].

Collections such as Bjork and Holopainen's [10] game design patterns or Barney's [9] pattern language alongside their community-developed online collections offer a wealth of relatively actionable patterns that can be applied to a variety of design goals. However, the work of Wetzel et al. [102], Power et al. [48, 73], and the Game Accessibility Guidelines Authors [8] demonstrates the potential of context-sensitive approaches in situations where the design goals deviate from a generally assumed 'norm', i.e., when designing for goals other than entertainment or for minority target groups. Here, we can see how a context-driven approach can be leveraged to support the use of game design patterns, and while these works show promise for their respective contexts, a comparable approach has not yet been taken for the context of physical therapy.

3.2.3 Approaches to Game Design in the Context of Physical Therapy. Existing work gives recommendations for the design of games for therapy and rehabilitation, mainly by providing implications or recommendations for design. For example, Flores et al. [25] recommend that adaptability to

[2] *Patterns in Game Design* online collection based on and mainly authored by Bjork and Holopainen [10], http://virt10.itu.chalmers.se/index.php/Main_Page. Retrieved August 30, 2024.

[3] Game design pattern collection based on Barney's [9] *Pattern Language for Game Design*, https://patternlanguageforgamedesign.com/PatternLibraryApp/PatternLibrary/. Retrieved August 30, 2024.

motor skill level is important to the design of games for stroke rehabilitation for elderly users. Aiming to support long-term engagement in games for health, Kayali et al. [55] state that feedback, representation of progress, and rewards are important factors, listing desirable features commonly found in games rather than providing concrete guidance with respect to their implementation. Similarly, Aufheimer et al. [7] investigated motivation in physical therapy for young people, and suggest, e.g., comprehensive set-up and calibration routines. However, these recommendations remain abstract, functioning mostly as guiding principles, and leaving room for interpretation when applying them rather than making direct connections with concrete game mechanics. A more technical perspective is taken by Geurts et al. [31], focusing on, e.g., input devices and the use of sensors in the development of games for users with motor disabilities. Focusing on serious games, Vanden Abeele et al. [99] developed a framework that provides guidelines for an iterative process of game conceptualization, design, and development.

Overall, we observe that approaches to the design of games for physical therapy remain abstract, either highlighting the relevance of specific features commonly found in games, or commenting on points for attention in the context of therapy without providing insights into how these might be translated into concrete game designs. In our work, we aim to close this gap through an exploration of how high-level recommendations for game design can be contextualized from the perspective of prospective players, and effectively operationalized by leveraging an existing set of game design patterns.

4 Step 1: Assessing and Refining the Key Lessons From Young People's Perspectives

Our ultimate goal is to show how high-level design principles such as Aufheimer et al.'s [7] key lessons can be used to guide the application of general design patterns to the specific domain of rehabilitation games. In this step, we sought to increase confidence in these key lessons by exploring them from the perspective of young people participating in physical therapy. As with Aufheimer et al.'s [7] original study, we leverage Self-Determination Theory [19] as a theoretical lens.

This step addresses *(RQ1): How do young people participating in physical therapy perceive motivational strategies employed by therapists, and what context do these young people's perspectives add to the game design process?* We employ qualitative research where young people participating in physical therapy were invited to take part in semi-structured interviews alongside a parent.

4.1 Theoretical Background: Self-Determination Theory

Deci and Ryan's [19] Self-Determination Theory (SDT) is, next to Csikszentmihalyi's [18] Flow theory, one of the most commonly applied motivational theories in HCI research [71, 97, 98]. Flow can be described as a psychological model concerned with the alignment of perceived challenge and skill, supporting states of prolonged engagement and deep focus. Specifically for the context of game-based exercising, the dual flow model by Sinclair et al. [88] expands Flow theory with a physiological component considering the alignment between exercise intensity and fitness.

Meanwhile, SDT is a macro theory focusing on motivation, well-being, and psychological functioning in different contexts described through its six sub-theories [3, 81, 82]. In line with the prior work [7], the two relevant sub-theories are Basic Psychological Needs Theory (BPNT) [82, p. 10ff., ch. 10][80, p. 326ff.][20, p. 233ff.] and Organismic Integration Theory [82, p. 19, ch. 8]. BPNT describes three basic psychological needs—autonomy, competence, and relatedness—as integral to human well-being and psychological health. OIT describes four forms of extrinsic motivation on a continuum of internalization, i.e, behaviors being executed to varying degrees for the sake of their outcome (e.g., praise or rewards).

While both theories are applicable to of our work, Flow and the dual flow model take a more narrow perspective on motivation through the figurative state of mind while the SDT sub-theories allow for a broader view of motivation and transitional stages of being motivated.

The application of SDT and specifically the support of autonomy have been found to be beneficial in various contexts related to physical therapy, e.g., in classroom settings [16, 75], school physical education [67], and physical therapy itself [72, 107]. However, works leveraging the theory thus far most often focus on functional outcomes rather than motivation as key aspect.

4.2 Methodology

We conducted semi-structured interviews with young people participating in physical therapy, accompanied by a parent, to assess and refine the key lessons. Through these, we aimed to complement the existing understanding of therapists' motivational strategies and their effects on how young people experience therapy independent of the use of games.

In line with prior work [29, 58] and the age range included in Aufheimer et al.'s [7] work, the recruitment age for young people was set to 6—16. This not only allowed for broad perspectives while ensuring a differentiated level of communication [85, 100, 104], but also aligns with the age range of clinics and practices specifically targeting young people in Germany, where care typically transfers to adults' services at the age of 18—20.

To ensure high-quality results, we leveraged Stenfors et al.'s [94] five criteria of trustworthiness of qualitative research: credibility, through drawing on SDT as theoretical background throughout the process; dependability, through detailed description of our process; confirmability through descriptions of our reasoning; transferability through the description of the context of the work; and reflexivity through iterations and discussions.

Our interview questions were based on the original key lessons (see Section 4.5), and were developed in line with the SDT sub-theories BPNT and OIT (see Section 4.1). We aimed for interviews to take approximately 30 minutes per participant pair. The interview guide started with questions regarding demographic information (e.g., the age of the young person and whether they were currently participating in physical therapy). Here, the participating parent was asked to confirm or clarify their child's answer. Questions then moved on to the young person's relationship with their therapist and their experiences with therapy. For example, the question *'Does your therapist give you feedback on how you are doing? [...]'* relates to the concept of *competence* and the theme of *'verbal encouragement and praise'* [7, p. 7], and *Key Lesson 2* [7, p. 13]. Similarly, *'Do you sometimes not want to go to therapy? Why?'* targets *amotivation* and *'children either see and understand the value of, or simply enjoy their physical therapy sessions'* [7, p. 9], and *Key Lesson 3* [7, p 13]. The guide closed with questions regarding goal-setting and an open exchange about the use of video games to supplement physical therapy, directed at both participants. For a full overview of our questions, refer to Section A of the supplementary materials.

When conducting studies with young people, ethical considerations are crucial. Previous literature emphasizes the importance of including young people's perspectives, particularly in studies concerning their health [91]. However, researchers must be cautious to avoid causing young people distress by reminding them of past difficulties related to their health conditions or treatments [101]. In our research, we prioritized ensuring the young people were comfortable when participating and parents feeling comfortable about the purpose, scope, and logistics of the study. To protect the young people, parents were asked to be present during interviews, as recommended in ethical guidelines for qualitative research involving young people [40]. However, this presence raised potential issues of power dynamics between young people and parents, and concerns about confidentiality and privacy [35]. Existing research offers strategies to address these challenges, such as empowering young people by adapting questions to their age and interests and managing parent-child dynamics

during interviews [40]. Throughout, the interviewer actively worked to balance power dynamics, encourage young people's independence, and adapt the interview process to the young people's needs. During data analysis, we carefully considered these dynamics, noting instances of parental involvement, and reflecting on their influence when interpreting and presenting results.

4.3 Participants and Procedure

Participants were recruited through clinics and practices providing therapy for young people, sports clubs, social media, and word-of-mouth. All parent-child pairs received a remuneration of 30 Euros (one parent participating alone chose to forego remuneration), and interviews lasted between 10 and 30 minutes. In total, nine young persons (mean age 11, SD =2.93) and eight parents (one parent participated with three of their children and one parent participated alone) participated in our interviews. All participants chose to take part via video call. Six young persons and four parents chose to participate in German, two young persons and four parents chose English, and one young person used a mixture of both. Table 1 gives an overview of demographic information.

Prior to the interview, parents were provided with study information and asked to provide written consent. At the start of the interview, a short summary of the study was repeated for the young person specifically, and they were asked for oral assent before the audio recording was started. The interview then proceeded as outlined in Section 4.2. The research protocol was approved by the Karlsruhe Institute of Technology data protection officer and ethics board.

Table 1. Participants' demographic information: the age of the young people, the type of therapy they engaged in (PT meaning physical therapy, OT meaning occupational therapy), whether they were actively participating in therapy at the time of the interview, and the duration for which they were in therapy. Participant P7 (marked with an asterisk) was a parent participating by themself, adding only their perspective to the data. Years abbreviated as 'yrs'.

Code	P1	P2	P3	P4	P5	P6	P7*	P8	P9	P10
Age	9	10	10	7	13	10	8	11	16	16
Type	both	both	PT	OT	OT	PT	PT	OT	both	both
Active	yes	yes	yes	yes	no	yes	no	yes	yes	yes
Duration	8 yrs	10 yrs	8 yrs	3 yrs	5 yrs	1 month	1 yr	3 yrs	8 yrs	8 yrs

4.4 Data Analysis

Data were analyzed following the deductive part of the hybrid thematic analysis described by Fereday and Muir-Cochrane [24], a less interpretative approach in comparison to, e.g., Braun and Clarke's [11] reflexive thematic analysis. We chose this approach, and to only conduct a deductive analysis, as the aim was to assess and refine the existing key lessons with young people's perspectives, providing the structure for analysis. This kept our analysis closer to participants' statements, allowing for the employment of Fereday and Muir-Cochrane's [24] method without sacrificing rigor. To maintain the connection with the theoretical lens employed in prior work, we based our a priori codes on the themes the key lessons were based on, and utilized the underlying SDT concepts [7, p. 7ff.] as theme categories that we could then connect back to the key lessons to close the circle. For example, the code *'getting feedback'* is defined as *'Therapists give feedback on the child's progress / performance.'* and described as *'Tracking of progress / performance over time, verbal communication relating to progress / performance, or communicating the progress / performance to caregivers.'*. Interview questions related to this code are, e.g., *'Does your therapist give you feedback about your performance? [...]'* or *'Do you remember a therapy session that was especially fun for*

you? What happened?'. The full set of codes, including a definition, description, and the interview questions relating to it, can be found in Section B of the supplementary materials. Data were coded and themes identified by the first author of this work. The analysis was then discussed with one of the other authors, adding perspective during the finalization of themes.

4.5 Results

Here, we present our results structured around Aufheimer et al.'s [7] original key lessons. The key lessons including addenda resulting from this study are summarized in Table 2.

4.5.1 Key Lesson 1: 'development of a more holistic perspective on adaptation in games for physical therapy' [7, p.13]. In this key lesson, Aufheimer et al. [7] emphasize therapists' practice of adjusting sessions based on situational factors and individual traits of patients. Our results show that the individual adjustments based on the therapists' relationship with the young people are an important factor and crucial to the young people's well-being and progress during participation. Some young people referred to changes in exercises and how **activities are conducted based on their situational preferences and needs**, offering insight into how their needs are being met in physical therapy. For example, P1 explained that *'Sometimes she [their therapist] adjusts [therapy], if we work on something [...] and if I like it, we keep going. But usually we do other exercises or the ones that I already know.'*, relating to their preferences sometimes being considered. On the other hand, our findings also suggest that some young people are unaware of adjustments, and do not explicitly mention any such actions, e.g., P2 saying *'no, I don't think so.'* when asked if their therapist makes any adjustments. This might be due to **therapists carefully balancing adjustments with therapeutic requirements**, as is supported by another young person's statement: *'I simply say that I can't anymore, and then they say "just a little more", and after that we, for example, go to the gym hall or something like that. Or, yeah, "just a little more and then you're done anyways" or we just stop. It depends.'* (P3).

Overall, even though **young people are unaware or only partially aware of adjustments**, our data supports the notion that physical therapists consider the needs of the individual young person within the framework of the therapy, and make adaptations accordingly. In light of the original key lesson, we further conclude that therapists appear to carefully choose whether to acknowledge adjustments towards young people. In turn, this leads us to believe that adjustments in games need to be considered and executed with equal care.

4.5.2 Key Lesson 2: 'viewing player performance through the lens of vulnerability' [7, p.13]. In Aufheimer et al.'s [7] work, this key lesson emphasizes therapists' practice of focusing on constructive rather than negative feedback to ensure positive experiences. From young people's perspectives in our data, we found that instances of failure are generally avoided through therapists' interference and narration of the experiences. For young people, the challenging nature of physical therapy may include repetitions of trying and failing at an exercise. Here, therapists reward positive outcomes and frame instances of failure as opportunities for trying again and 'getting there'.

Relating to this key lesson, our data supports the assumption that **therapists use a variety of ways to reward young people and to avoid perceived failure**, e.g., getting sweets or doing fun activities. How young people perceive the relationship between achieving a positive outcome and getting rewards differs between individuals. For example, P5 explained they get sweets *'if [they] did well'* and P3 says they are *'[...] allowed to give food to the horses at the end, because they get a reward too.'*. Some young people also perceive rewards as part of physical therapy, but do not relate them to their exercise achievements: *'Yes, but it's because the prescription is full [they did the prescribed number of sessions], not because I did well in therapy.'* (P4).

Even if receiving a reward is not connected to the young person's performance, therapists avoid direct negative feedback and use positive reinforcement in instances of failure. This is applicable for both the feedback directly given to the young people and the feedback parents receive about their child's performance. For example, *'He [the therapist] always says that I'm doing well. He goes to [the parent] and also says that I've done really well.'* (P6). However, some parents highlight that they do receive negative feedback: P4's parent remarked to their child during the interview that *'She [the therapist] also tells me that in the end, right? If it's all been easy for you or if sometimes you misbehaved a little.'*, expanding on their child's hesitant acknowledgment of receiving positive *and* negative feedback. When addressing young people, **therapists make sure to frame failures in a way that suggests to the young person that they will eventually accomplish the task**, even if they struggled at that moment: *'Some things I can't do, can't do well, but we practice that and I know I'll be able to do it soon.'* (P1), *'Most of them say "wow, well done" if I do well, and if I don't do well, they say "let's try this again, you can practice that".'* (P3) or *'[They] just say "great work, keep going, it'll be better".'* (P9).

Summarizing these results, young people's statements show that negative feelings around therapy are avoided, and positive experiences are reinforced through different types of rewards and feedback.

4.5.3 Key Lesson 3: 'games as an opportunity to increase patient self-determination' [7, p.13]. Here, Aufheimer et al. [7] highlight the frequent lack of meaningful provision of autonomy in physical therapy. It typically requires repetition and consistency, which often stands in contrast to self-determination and autonomy, especially for young people attending long-term physical therapy. Young people's accounts of reasons for attending physical therapy are in line with the original findings: Some young people are unaware of the specific reason they are in physical therapy, stating that they *'[...] just do it.'* (P2) while others are conscious about medical reasons and benefits they draw from their participation, e.g., *'Yeah, I know exactly why I go there, because of my right arm and right foot. And, well, because since birth my right side has a disability.'* (P1).

Similarly, **most young people report not having a say in the specifics of therapy or being involved in the process**, with some stating that *'it's okay for [them]'* (P8) because they enjoy therapy overall, while others are more critical, e.g., *'Sometimes I don't want to do an exercise but do it anyway.'* (P1) or *'[...] sometimes it's boring because I have to do the same exercise for so, so long.'* (P6). We found that **some therapists try to avoid this by engaging in collaborative goal-setting**, e.g., *'We make a plan of what we're going to work on in the morning and I also say what I want to do.'* (P2) or letting young people decide on minor aspects regarding the structure, e.g., *'The order, so, for example, I only named two, but you definitely have to do the one thing and then the other, because both have to be done. [...] but you can pick the order in which they are done.'* (P3). However, with increasing age, young people may wish for more consideration: *'They should try more, and if [the goal is] not realistic, just find a way to implement it until you come [to] realize it's not realistic.'* (P10).

Overall, young people appear to have at least some sense of autonomy, albeit limited by the structure and requirements of physical therapy, and therefore often limited to non-essential aspects. Here, games may offer a way to increase autonomy, allowing young people to make choices that would not be possible otherwise, such as changing the setting or mapping one's physical actions onto different actions within the game.

4.5.4 Key Lesson 4: 'recognizing the limitations of game-based physical therapy and the unique value of human-led approaches' [7, p.13]. In this key lesson, Aufheimer et al. [7] call for acknowledging the unique value of human-led physical therapy due to therapists' expertise. Overall, few young people commented on their experiences with human-led therapy in comparison to game-based therapy. One parent shared their experience with a medical gaming system at home: *'We had the Galileo [a medical gaming system] at home, with a point system where [the young person] could*

pick something every so-and-so many points. But over time, the incentive wasn't high enough to keep using it at home.' (P2). This example illustrates that **prolonged engagement and motivation to consistently attend physical therapy is a complex subject**, oftentimes requiring more than a playful setting and reward system. Therapists carefully work towards building motivation for physical therapy in collaboration with the young people (see also the results on Key Lesson 3) and strengthen engagement through individualized positive reinforcement (see also the results on Key Lesson 2). **From the perspective of young people, their relationship with their therapist is an important factor.** Reflecting on this relationship, P5 stated that participating in physical therapy *'[Is] okay. Also because I really liked everyone there.'* when asked if they liked attending physical therapy, and the parent of P7 stated that their child *'is usually shy with people, but [they] didn't seem to have much of a problem going to [physical therapy].'*. While most accounts only mention interactions between young people and parents, and young people and therapists, some also highlight the mediating role of parents. We observed different approaches where some parents choose not to get involved, while others relay tasks their child struggles with in everyday life to the therapist (e.g., *'[...] for example the school would let me know that [...] like the thing with the pen and such, those are things I have told them, and they then decided what exercises to do for that.'*, parent of P5). Overall, our data paints a picture of a trusting relationship between young people, parents, and therapists: Parents often choose to not intervene, follow the therapists' decisions, and give space to their children to act with agency within the boundaries defined by the therapeutic context. In turn, this also shows the need for therapists' expertise and experience which cannot be substituted with games, which is further supported by the very limited experience young people had in using games for therapy.

Table 2. Summary of observations from our analysis, alongside the original recommendations and addenda resulting from our study.

Key Lesson 1: development of a more holistic perspective on adaptation in games for physical therapy	
Observation Young people's perspectives suggest that therapists carefully adjust sessions towards their needs. However, it appears that therapists tend to do this in a way that leaves young people mostly unaware of the connection to their individual preferences and needs.	**Recommendation** The original key lesson recommends exploring manual approaches to measure situational factors (e.g., [27]), and emphasizes the need for comprehensive set-up and calibration routines [7, p. 13]. **Addendum** In addition, we recommend careful consideration of how adjustment mechanics are implemented: automatic adjustment that is noticeable may lead to negative feelings. We therefore suggest keeping adjustments manual, as an option for therapists to select. This empowers therapists to let young people know about the adjustment in cases where they expect the young person to feel encouraged or to keep it hidden otherwise.

Continuation of Table 2.

Key Lesson 2: viewing player performance through the lens of vulnerability

Observation	**Recommendation**
Young people rarely experience negative emotions during therapy: The concept of failure is present only in cases where it is motivating to the individual, i.e., the decision to adjust challenge is based on characteristics of the individual, and their positive experiences are reinforced through feedback and rewards.	Our recommendations here align with the original key lesson [7, p. 13]: Game design in this context should avoid strong feelings of failure, and focus on positive, reinforcing feedback, qualitative performance indicators, and rewards. Further, feelings of competence should be enhanced, e.g., by balancing new tasks with already known and successfully performed tasks based on the individual's response to challenge.

Key Lesson 3: games as an opportunity to increase patient self-determination

Observation	**Recommendation**
Young people rarely experience meaningful autonomy in the context of physical therapy but also do not seem to mind this lack overall.	In line with the original key lesson [7, p. 13], we recommend games as a way to increase autonomy in the context of physical therapy.

Key Lesson 4: recognizing the limitations of game-based physical therapy and the unique value of human-led approaches

Observation	**Recommendation**
Our data shows the unique value of the relationships between parent and child, and therapist, based on trust, human connection, and the awareness that therapists act in the young person's best interest based on their experience and knowledge.	Similar to the original key lesson [7, p. 13], we recommend viewing games as a supplementary technology to human-led therapy. **Addendum** We further suggest careful consideration of the use of games in each individual case, especially if at-home use is intended.

5 Step 2: Operationalizing the Key Lessons Using Game Design Patterns

In this section, we lay out our approach for the operationalization of the key lessons and addenda from *Step 1* to address *(RQ2): How can high-level implications for design be operationalized into actionable guidance for the design and analysis of games for physical therapy?* Based on our review of related work (see Section 3), we decided that game design patterns would be an appropriate way of associating high-level recommendations with concrete guidance for designers. Our initial attempt was to categorize Bjork and Holopainen's [10] game design patterns along the key lessons. However, we identified several shortcomings in this approach (see Section 5.1), and so present an alternative operationalization in which the key lessons are applied as a lens to reflect on game design patterns (see Section 5.2).

5.1 First Attempt: Strictly Categorizing an Existing Set of Game Design Patterns

This section describes our initial attempt at strictly categorizing game design patterns along the key lessons. The aim of this step was to deduce a set of 'best practice' patterns on the basis of

existing game design considerations that could be recommended for the design and analysis of games for physical therapy for young people.

5.1.1 Methodological Approach. We chose Bjork and Holopainen's [10] game design patterns as widely cited, well-documented, and vast collection of 296 patterns describing possible design choices regarding, e.g., game elements or possible actions. Each pattern is described alongside examples of its implementation in existing games, consequences of its application, and relation to other patterns. We set out to categorize the patterns along the key lessons while accounting for the underling constructs of BPNT and OIT (see Section 4.1) to add detail to our categorization and to ensure that the concepts underpinning the key lessons are present in the patterns.

To support categorization, each pattern was graded on whether it could be associated with each individual key lesson (including our addenda, see Table 2) and the underlying BPNT and OIT concepts, using an approach derived from affinity diagramming as described by Holtzblatt [43] which has been similarly applied in prior work [26, 38, 41]. Based on this step, the author conducting the initial categorization then assigned a marker of how confident they were in their decision. These variables were then used by the author to categorize each pattern as suitable, not suitable, indecisive, or irrelevant, before sharing the categorization with two of the other authors for discussion.

5.1.2 Results. The initial categorization resulted in 110 patterns aligning with the key lessons, 33 patterns being associated with negative implications, 45 patterns with mixed association, and 108 patterns not being relevant in the context of the key lessons. For example, the pattern *Progress Indicators* [10, companion disk] would serve as an example of Key Lesson 2, lending more concrete inspiration to designers when wishing to implement it.

However, when engaging in discussion, two things became apparent: First, no patterns were directly associated with Key Lesson 4, stating that the limitations of games and the unique value of human-led therapy need to be considered. We therefore argue that this key lesson should be a prerequisite to the process of game design to help stakeholders decide whether a game is an adequate solution. Second, we found that perspectives towards the association of the patterns with the remaining key lessons varied; many of the patterns could be implemented in a beneficial or disadvantageous way with respect to the key lessons and the context of physical therapy. Depending on the experience or perspective of the designer, our discussion revealed that patterns would need to be considered with more nuance than our strict categorization would permit. Examples illustrating these discussions can be found in Section C of the supplementary materials.

Based on this, we conclude that approaching *(RQ2)* by strictly categorizing a vast set of patterns yields insufficient results. We argue that whether a pattern is beneficial to motivation in the context of physical therapy expressly depends on how it is implemented. However, our discussions inspired our second attempt—utilizing the refined key lessons as a lens to add structure to the discourse—which is described in the following.

5.2 Second Approach: The Key Lessons as a Lens on Games for Therapy

To apply the key lessons as a lens, we utilized them alongside their related BPNT and OIT concepts to consider different perspectives and structure our thoughts—an approach not unlike Schell's [86] well-known lenses, motivated by the author's criticism that most academic approaches are restrictive and inflexible in the face of changing circumstances and context. This criticism is mirrored by Kuittinen and Holopainen [59] in their argument that designers need to understand the context for which they design. Here, the key lessons can provide guidance to the creative process, helping designers to carefully consider the impact a pattern may have for the context of physical therapy for young people. Ultimately, this can help limit the design space in a way that supports designer's understanding

of the context and informed decision-making. Based on the results from our first attempt (see Section 5.1), we exclude Key Lesson 4 from this approach as it addresses the appropriateness of games as a solution in the first place, presenting a prerequisite to the game design process.

5.2.1 Methodological Approach. Building on our learnings from the previous attempt, we found utilizing the key lessons and addenda (see Table 2) as a lens to structure reflection on game design patterns to be a promising tool. Excluding Key Lesson 4 for the aforementioned reason, the first author selected example game design patterns matching each of the remaining key lessons for analysis. Patterns were selected either based on keywords corresponding to the key lesson or because they were categorized as aligning with the key lessons in the first attempt (see Section 5.1). Given that we did not want a characterizing list of patterns, we felt that this approach was rigorous enough to produce a set of suitable examples. Subsequent analysis was carried out by four of the authors with experience in game design, accessible gaming, and games for physical therapy for young people. They each asynchronously took notes of their considerations, potential benefits of a pattern, and ways in which a pattern may be disadvantageous.

5.2.2 Results. We now summarize the four authors' assessments and considerations for the example patterns (see Table 3 for an overview, and Section D of the supplementary materials for additional examples).

Table 3. Overview of the selected example patterns for each key lesson alongside their book reference and selection criteria. Abbreviation KL = Key Lesson.

KL	Pattern	Reference	Selection Based on
1	Right Level of Difficulty	[10, Ch. 14, p. 392ff.]	keyword 'difficulty'
2	Competence Areas	[10, Ch. 10, companion disk]	keyword 'competence'
3	Freedom of Choice	[10, Ch. 9, p. 209ff.]	keyword 'choice'

Key Lesson 1: 'development of a more holistic perspective on adaptation in games for physical therapy' (see Section 4.5)

Example Pattern: *Right Level of Difficulty*, the game being neither too easy nor too difficult. Ensuring the right level of difficulty is particularly complex in games for physical therapy, as young people's abilities vary greatly and may even differ from day to day. Important aspects to consider in this context are the appropriate challenge to progress towards therapeutic goals, and the challenge being in line with surrounding factors, e.g., young people's willingness to exercise, while avoiding overexertion. Here, a linear approach to difficulty is often inappropriate, while dynamic adjustment algorithms can not (yet) account for all connected variables in the way therapists do. Prior work has shown that although shared determination of difficulty is important, patients may make decisions that are counter-productive to therapeutic goals, and close attention needs to be paid to ensuring a beneficial application [51]. Further, challenge and difficulty are two-fold in games for physical therapy and need to be carefully balanced: The therapeutic goals and challenges should not be overshadowed by (often cognitive) gameplay challenges; however, gameplay challenges are an essential part of what makes games engaging. To support this key lesson, difficulty needs to be carefully constructed in a modular way, allowing therapists to make adjustments based on a young person's affective state and at runtime.

Key Lesson 2: 'viewing player performance through the lens of vulnerability' (see Section 4.5)

Example Pattern: *Competence Areas*, the option for different game entities to have specialized abilities. This pattern aligns well with ability-based training approaches, allowing players to expand

on their skills (e.g., [74]). However, this raises the question of how to target skills that players may struggle with and need to practice—an activity that is typically less desirable. If an implementation presents options for competence areas based on past performance, it may lead to a positive feedback loop and could be tied to progression, e.g., the more players perform an action, the better they get at it, and the harder the exercises for this action become. This, in turn, can help push players towards performing actions outside their competence areas: being good at something and progressing may give players the confidence and motivation to also practice other skills. Yet, balancing this pattern with therapeutic requirements is not straight-forward: Illusory effects may be leveraged, but may lead to frustration if players become aware. Conversely, tying competencies to physical activity requires designers to consider how to make less desirable interactions more appealing to prevent unbalanced training.

Key Lesson 3: 'games as an opportunity to increase patient self-determination' (see Section 4.5)
Example Pattern: *Freedom of Choice*, players being able to make choices in the game. Choices need to be present for a game to be a game, so that players can affect the outcome; the degree of freedom is, however, subject to change. While this pattern intuitively supports this key lesson, it is quite broad and therefore potentially hard to apply. The key lesson itself also offers no guidance in which way autonomy should be supported, i.e., what meaningful support of autonomy would look like in the context of physical therapy. However, prior work by Richards and Graham [78] specifically examined this question and found that therapeutic requirements may conflict with the provision of meaningful choices. Here, the illusion of choice or influence (e.g., through cosmetic choices or choices that do not actually affect gameplay) may help balance this tension, though this would only support this key lesson on a surface level. What choices can and should be offered remains a question that needs to be answered in close collaboration between designers and therapists, considering the specific aim of the designed game.

Overall, we found that the process of discussing game design patterns through the lens of the key lessons was actionable and lead to engagement with the discussed patterns on a deeper level. For example, each individual author not only considered the patterns from different perspectives (e.g., What does a given pattern entail for young people playing it? What does it entail for therapists supervising play?) but also reflected on implications beyond the straight-forward implementation of a pattern (e.g., choices need to be curated in a way that keeps young people from making choices that are harmful in their specific situation). Here, the value of our discussion lay especially in the different perspectives on games and physical therapy that each author added.

6 Step 3: Applying the Key Lessons

Building upon our operationalization approach presented in Section 5.2, we applied the key lessons from *Step 1* to existing gaming systems used in the context of physical therapy. Here, we changed perspective from the design of games for physical therapy (see *Step 2*, Section 5) to reflecting on implementations of patterns in existing games, adding to our answer of *(RQ2): How can high-level implications for design be operationalized into actionable guidance for the design and analysis of games for physical therapy?* We examined the applicability of the key lessons as a lens to the analysis of games, considering their potential not only for game design, but also for critical appraisal of existing games. We first lay out our approach, before describing the results of the analysis of two example gaming systems, each covering a distinct category of game: (1) *Liberi* [37], a rehabilitation game that was developed as part of a research project, and has been positively evaluated and well-covered by HCI literature (e.g., [37, 52], see also Section 3.1). (2) The commercially available game *Wii Fit* [23], which has been widely and successfully used in physical therapy despite not

being designed for this purpose (e.g., [50, 96]). The application of standard commercial games in physical therapy is a particularly interesting opportunity [17].

6.1 Methodology

For each example gaming system, one of the authors conducted the analysis. If not already familiar with the details of the system, they engaged in a play session of about 60 minutes. Both authors took notes on how game elements relating to the key lessons (see Table 2) were implemented. Based on these notes, the author conducting the analysis determined which one of Bjork and Holopainen's [10] patterns would most reflect the feature at hand and analysed the implementation of the associated pattern through the lens of the key lessons.

We present details on each of the games and the results of the analyses grouped by key lessons in the following two sections. Key Lesson 4, regarding the unique value of human-led therapy, is omitted in the analyses as a key lesson that should be considered as a precursor to the design of games for physical therapy (see Section 5.2).

6.2 Example 1: Liberi

Liberi is an exergaming system designed around the abilities of young people with neurodevelopmental disorders. The game has been demonstrated to improve cardiovascular health [58] and reduce perception of pain post surgery [13] in young people with cerebral palsy, to improve executive function in young people with fetal alcohol spectrum disorder [87], and to lead to positive social interaction in young autistic persons [33].

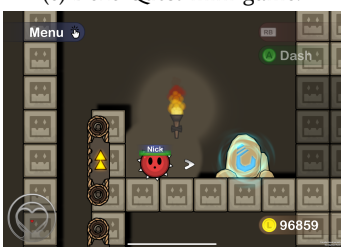
Liberi is played using a custom-designed recumbent bicycle [36], where players pedal to move their game avatar. Players play several mini-games in small groups, accessing the games from a central island. The island includes shops where the players can buy cosmetic avatar upgrades using coins they earn from playing the games (Figure 1a). For example, in the *Gekku Race* mini-game, players race up a wall, and can spit cashews and breathe fire to slow down people who are ahead of them (Figure 1b). In *Dozo Quest*, players are spiky balls that traverse a maze and collaboratively defeat a boss monster (Figure 1c).

Fig. 1. Screenshots of the Liberi exergaming system.

(a) *Shop* offering cosmetic avatar upgrades.

(b) *Gekku Race* mini-game.

(c) *Dozo Quest* mini-game.



6.2.1 Key Lesson 1: Adaptation. The games can be customized to the abilities of players, for example adjusting how hard the player needs to pedal the bike based on their Gross Motor Function Measurement [61] or adjusting what accuracy is required with a joystick [46]. This form of adaptation is an example of the *Right Level of Difficulty* pattern [10, p. 392ff.]. The pattern is applied to

players' ability to physically carry out rehabilitation exercises, rather than the pattern's intended application to gameplay ability.

The *Gekku Race* mini-game (Figure 1b) is time-limited to provide a consistent therapy duration, so that all players pedal for the same amount of time regardless of their individual ability. To ensure a consistent play duration, the length of the track is automatically adjusted so that the player reaches the end at exactly the desired time, while simultaneously avoiding potentially negative feedback. Players do not see the entire track and remain unaware that its length is being dynamically adjusted. This is an example of how the *Time Limits* pattern [10, companion disk] can be adapted to ensure the correct duration of rehabilitation exercises.

Finally, players are rewarded in-game with power-ups for maintaining their target heart rate [56]. These give their avatar extra abilities and a more exciting appearance. The power-up lasts only as long as the player stays within a therapist-determined heart rate zone. Since all players are equally able to reach their heart rate targets (because they are customized to the player), these power-ups do not confer an advantage to stronger players. This is an example of the *Power-Ups* pattern [10, p. 88ff.], adapted to the achievement of therapeutic goals rather than gameplay goals.

6.2.2 Key Lesson 2: Feedback. Feedback can be provided in many ways consistent with therapeutic goals. For example, players receive coins for completing games, showing them that they have successfully completed a task that is considered valuable. The coins can then be used at shops to buy outfits for the player's avatar (Figure 1a). The ability to collect outfits provides players with positive feedback around engagement in therapy and allows them to show their success to others. This is an example of the *Outcome Indicators* pattern [10, companion disk], tied to the players' completion of therapy tasks, as opposed, e.g., to more traditional score displays (*Scores* pattern [10, p. 94ff.]). This shows how the *Rewards* pattern [10, p. 184ff.] can be used as a form of outcome indicator.

6.2.3 Key Lesson 3: Self-Determination. Liberi implements the *Freedom of Choice* pattern [10, p. 209ff.] in several ways, providing an open world experience where players are able to guide their own gameplay. For example, players can choose what mini-game to play and whether to play alone or with others. After collecting coins, they can choose what kind of avatar outfits to purchase, or can choose to save their coins for later.

Within the mini-games themselves, freedom of choice may be illusory (*Illusion of Influence* pattern [10, p. 201f.]). For example, in the *Dozo Quest* game (Figure 1c), players navigate a maze. All branches of the maze lead to the same place, however, so that players cannot get lost. There is therefore no real choice as to where to go, despite players being given the illusion that choice exists. Illusion of Influence is a powerful tool in rehabilitation games, where therapists require players to engage in certain activities for a given amount of time, therefore giving little agency to players.

6.3 Example 2: Wii Fit

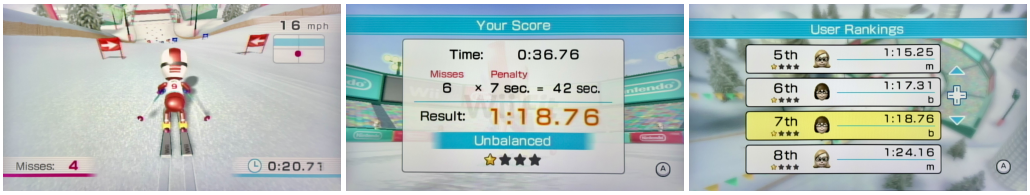
Despite being a commercial system intended for general at-home exercise, *Wii Fit* [23] (used with the *Wii Balance Board* [66]) has been shown to be effective in supporting physical therapy in young people [50, 96]. Works investigating the applicability of the system in the context of physical therapy in tightly controlled research settings found functional improvements in balancing skills [50, 96] and young people with cognitive disabilities enjoying the intervention [50].

The system comprises various mini-game categories, of which the *Balance Games* are typically used in the context of physical therapy for young people. Here, we use Jelsma et al.'s [50] work as guidance and focus our analysis on the same mini-games that the authors applied in a therapeutic context: the *Ski Slalom* mini-game where players have to steer their character to go between poles by shifting their weight left and right (see Figure 2a); *Tightrope Tension*, where players have to

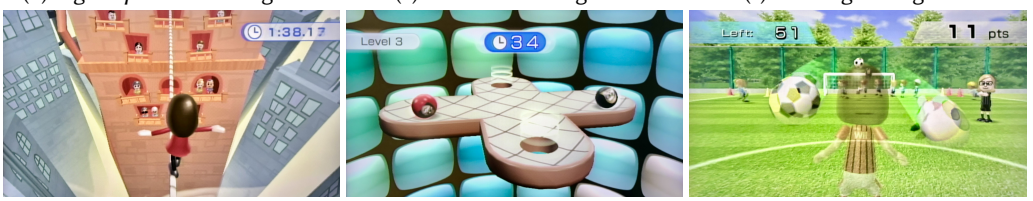
balance and walk their character on a rope by making a walking motion, and jump over enemy characters by bending and extending their knees (see Figure 2d); a *Table Tilt* mini-game, requiring players to shift their weight in all directions to steer marbles into holes on a platform (see Figure 2e); and *Heading*, where players are supposed to tilt their body from side to side to hit a ball with their head, while avoiding hitting other objects, e.g., shoes (see Figure 2f).

Fig. 2. Screenshots of the four *Wii Fit* mini-games played for the analysis, and an example of the score overview and leaderboard from *Ski Slalom*. Comparable overviews are also provided by the other mini-games.

(a) *Ski Slalom* mini-game. (b) *Ski Slalom* score overview. (c) *Ski Slalom* leaderboard.



(d) *Tightrope Walk* mini-game. (e) *Table Tilt* mini-game. (f) *Heading* mini-game.



6.3.1 Key Lesson 1: Adaptation. To start training with *Wii Fit*, the system requires players to go through a lengthy registration process where the game asks players for their age, measures their weight, and has them perform a *Body Test* (two randomly selected tests from a set of five, e.g., balancing on one leg or keeping as still as possible [103]), before finally asking players to set a weight change goal. However, this set-up routine is not used to calibrate the game to specific player needs, instead serving to track activity levels and progress over time. It therefore relates less to adaptation and more to patterns such as *High Score Lists* [10, p. 96f.], ranking players' attempts against others' or their own.

A prominent option provided by *Wii Fit* for adaptation is the selection of a difficulty level from either two or three options, depending on the game. Selectable difficulty levels are an example of the *Handicaps* [10, p. 396ff.] pattern, balancing gameplay difficulty in a way that all players have a similar chance to succeed in the game. Viewing this pattern and its implementation in *Wii Fit* through the lens of Key Lesson 1 shows a lack of ability to adjust the game to an individual's needs: In all mini-games, even the *Beginner* difficulty setting was already challenging for the non-disabled adult researcher conducting the analysis, from which we conclude that a young person needing to practice balancing skills would likely struggle to achieve the goals of the games. This may lead to a frustrating experience that contradicts Key Lesson 1.

6.3.2 Key Lesson 2: Feedback. All mini-games show typical audiovisual feedback for successful and unsuccessful actions and gameplay outcomes. Here, we focus on two specific feedback mechanisms implemented at the end of a gameplay round: A score overview and leaderboard, instantiations of

the patterns *Scores* [10, p. 94ff.] and *High Score Lists* [10, p. 96f.], ranking players' attempts against others' or their own. Figures 2b and 2c show an example of these from the mini-game *Ski Slalom*.

The unit of measurement for the scores differs between mini-games, e.g., the score in *Ski Slalom* is the time players take to reach the bottom of the course with added penalty times for missed gates, and the score in *Table Tilt* is 10 points added up for each cleared level. However, all mini-games rank player performance on a scale of four stars and additionally name the ranking as *Unbalanced*, *Amateur*, *Professional*, or *Champion*. In all mini-games, scores are added to a leaderboard shared among players. The judgmental nature of the star-ranking and its verbalization are possibly frustrating and discouraging when viewed through the lens of Key Lesson 2. Further, the shared leaderboard is a questionable feedback mechanism in the context of physical therapy: Young people's abilities vary greatly and comparing their performance to that of others could be detrimental to their self-esteem.

6.3.3 Key Lesson 3: Self-Determination. The mini-games themselves do not offer ways for players to determine their own course of action. The mini-games follow a linear progression, and there are no alternative paths for players to take in order to reach the goals.

The only choice offered to players is which mini-game to play. This influences the setting in which they perform their exercises, which is an example of the pattern *Levels* [10, p. 60ff.]. As all games target balancing skills, players still have to perform the same exercises overall, thus making the choice illusory. In theory, players are also able to choose their desired difficulty level; however, in the context of physical therapy, it is unlikely that young people would be making this choice autonomously.

7 Discussion

We first summarize our findings in the context of our two research questions. We then discuss the need for nuanced guidance when creating or analyzing games for therapy, and reflect on the role of implications for design in the context of HCI games research.

7.1 RQ1: How do young people participating in physical therapy perceive motivational strategies employed by therapists, and what context do these young people's perspectives add with respect to game design?

In the first step of our research, we set out to contextualize design guidance articulated through the perspective of therapists from the viewpoint of young people taking part in physical therapy. Our results show that young people's perspectives on motivational strategies in physical therapy were consistent with those of therapists. Adaptation and encouraging feedback were crucial for a positive experience, which is in line with Key Lessons 1 and 2. Restriction of young people's autonomy with respect to core aspects of therapy underscores the relevance of Key Lesson 3. Interestingly, we observed that adaptations made by therapists often went unnoticed by young people. This shows that game designs making adaptations explicit may need to be aware of potential negative consequences for player experience, similar to those sometimes observed in player balancing [30]. This adds nuance to Key Lesson 1 which thus far had focused on the importance and benefits of adaptations.

7.2 RQ2: How can high-level implications for design be operationalized into actionable guidance for the design and analysis of games for physical therapy?

In our work, we sought to operationalize design recommendations for games for therapy by leveraging existing game design patterns, connecting high-level guidance with concrete game mechanics and approaches to game design. We observed that many guidelines left room for

interpretation which became evident in the analysis of example patterns in existing games (see Section 6). However, the lessons did provide valuable focus points for critical appraisal of games with respect to motivational strategies. For example, they revealed that the use of *High Score Lists* [10, p. 96f.] in *Wii Fit* [23] contradicts therapists' approaches to reduce instances of failure (see Section 6.3), and that *Liberi* [37] broadly leverages illusory effects of player actions through *Illusion of Influence*[10, p. 201f.], aligning with therapists' strategies (see Section 6.2) and providing some choice through the freedom of movement rather than a choice in, e.g., goals or influence over the outcome [83]. While perceived autonomy enhances intrinsic motivation, we found the meaningful operationalization of autonomy a particular tension in the context of the comparably tight structures of physical therapy that needs to be considered. Still, existing approaches possibly forgo some of the benefits that games could offer with respect to autonomy, e.g., by instilling a sense of volition or willingness through offering (perceived) opportunities to engage in activities that interest players, and utilizing rewards as a feedback mechanism rather than to control player behavior [83].

The need for interpretation was likewise evident when attempting to pair the key lessons with concrete examples of game mechanics (see Section 5.2). Here, interpreting patterns through the lens of recommendations for design was more practical, but still relied on designerly knowledge and an understanding of the intricacies of physical therapy, a challenge which we discuss further in the following section. Overall, we conclude that the process is not as straightforward as initially assumed, highlighting the wider challenge of filling the gaps when working with implications for design.

7.3 Reflections on Implications for the Design of Games

As in many domains of HCI, the games research community has long considered implications for design to be a core research contribution (e.g., see [6] and [34]). Yet, less is known about the practical value of such recommendations for future research, which we discuss here.

7.3.1 Acknowledging The Need for Nuance When Designing Games for Therapy. Our exploration has refined and operationalized high-level recommendations for the design of games for physical therapy. A key takeaway from this work is the need to approach game design with nuance, carefully weighing design choices at the level of game mechanics, their interplay in the context of gameplay, and consequences for therapy. This has previously been discussed in the game design community; e.g., Kuittinen and Holopainen's [59] comments on the relevance of designers understanding the design situation, and Schell's [86] remarks on the importance of understanding and clearly communicating complex ideas of the game design process. Likewise, it is acknowledged that in games for therapy, small design decisions can have major impact [47, p. 17]. Here, our exploration shows that high-level guidance in particular leaves ample room for interpretation; in our analysis, this led to the application of knowledge acquired in past projects to help interpret recommendations for the design of future projects. Guidance from previous work by Sas et al. [84], who considered implications for design in design research, likewise highlights the relevance of actionability of recommendations. The authors suggest that a *'specific useful combination of two types of design implications supporting design practice, is abstract functionalities combined with their instantiations.'*. Here, Isbister and Mueller's [49] work on guidelines for the design of movement-based games offers an interesting example of how this can be approached, not just supplying examples, but also offering *dos and don'ts* that serve as a prompt for consideration of the design situation. In our work, however, we question whether these approaches reach far enough: Physical therapy for young people is complex, and so is game design, creating a situation in which guidelines may give the illusion that they can replace years of practical experience and familiarity with both domains.

This aligns with Dourish's [21] criticism of implications for design risking oversimplification, an issue which remains largely underexplored in the design of games for therapy today. We therefore encourage designers to embed themselves in the field in an effort to contextualize their assumptions of typical design patterns (e.g., regarding failure) when designing for therapeutic contexts. We believe this is achievable through the combination of comprehensive design recommendations with participatory design processes that draw on the knowledge of domain experts.

7.3.2 Leveraging Static Recommendations to Design Highly Interactive Systems. Games are highly interactive systems in which gameplay and player experience only emerge in interaction between players and game [92]. In addition, interactions between game mechanics within a game need to be considered when seeking to facilitate a specific experience: For example, increasing autonomy by allowing players to choose in-game tasks and broadening the scope of gameplay (see Table 2, Key Lesson 3) may increase the risk of failure, potentially contradicting other guidance (see Table 2, Key Lesson 2). Here, recommendations for design need to make an explicit effort to highlight that the subsystems of a game do not exist in isolation, and that the mere presence of a mechanic does not guarantee a specific player experience (also see extensive considerations on this issue in the context of gamification [64]).

Considering Dourish's [21] previously discussed and widely acknowledged criticism of implications for design, this highlights an interesting challenge in the context of HCI games research: Dourish [21, p. 548] originally focused on the process of establishing requirements using qualitative methods, criticizing that implications for design *'clearly fail to capture what an ethnography captures'* because they (among other issues) *'locate the topics of interest outside of the relationship between ethnographer and subject'*. While we do not disagree with this argument, we believe that it needs to be expanded beyond the process of requirements establishment to an iterative process of integration and reflection. Particularly in the case of games, implications for design may also be inadequate to capture the complexity of gameplay, i.e., the effect a particular *combination* of mechanics has. While the role of adaptation to aspects such as player traits or emotion have previously been discussed (e.g., see [68] and [70]), there is little reflection on the interplay between different game mechanics. In particular, there needs to be awareness that an experience only ever emerges at runtime of a game, thus requiring this stage to be part of the establishment process. Despite the inherent challenges of static recommendations they can offer valuable lenses to inform design choices and analysis of games, especially when employed in iterative and participatory processes where they can be complemented by the context and experiences of domain experts.

8 Limitations and Future Work

The findings of this work have to be seen in light of a number of limitations. First, due to the qualitative research approach, the interview study included a relatively small number of participants. We also observed that some young people shied away from questions, requiring us to rely on accounts of parents. Further, while biological age and chronological age may vary greatly in populations receiving physical therapy, our sample was heterogeneous, and we did not closely investigate age disparities. This needs to be kept in mind in the context of game design (e.g., differences in preferences resulting from age differences), and should be approached by future work with additional nuance and care. Likewise, we have not yet studied long-term perspectives, or differentiated factors such as different disabilities or comorbidities in our investigation. Future work could contribute a broader study of young people's views towards physical therapy, e.g., a field study on-site where young people would have the opportunity to get to know the researcher over the course of multiple sessions, also allowing for meaningful investigation of specific differences (e.g., different disabilities).

From a methodological perspective, the underlying concepts of the original key lessons had to be abstracted to the level of understanding of young people in the interviews, which may have introduced biases. Future work could address this through application of the key lessons in games, and shared exploration with young people. When operationalizing the key lessons, we considered Bjork and Holopainen's [10] collection of patterns to exemplify our approach. While this was an explicit choice in our effort to deduce actionable guidance, future work should investigate whether applying the lens to different resources (e.g., game design frameworks such as MDA [45]) can enable researchers to define a set of 'best practice' patterns and strategies for the context of physical therapy. Finally, a relevant future direction is to design and develop a game employing the key lessons throughout the process, closing the circle by evaluating them in the context of game development, thus being in a position to fully evaluate the actionability of the initial design guidance.

9 Conclusion

Our work has explored the refinement and operationalization of design recommendations for therapeutic games for young people. When designing and developing games for the context of physical therapy, best practices in game design and therapeutic practice need to be carefully considered, and they need to reflect perspectives of game design, therapy, and patient experience. In our work, we have begun to address this challenge by contextualizing recommendations for the design of games for therapy on the basis of patient feedback obtained through an interview study, and a theoretical appraisal of existing game design patterns. Our work underscores the importance of acknowledging the complexity of game design for therapy, and should be understood as a reminder to carefully engage with the context and the communities for whom designs are intended. We therefore consider our work to be a first step towards better communicating design guidance for games in sensitive settings, and we invite the HCI and games research communities to engage in critical conversation on how to make recommendations for design actionable, while also ensuring that application takes place with the care and nuance that is required when creating games to support physical therapy.

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