

# An Examination of Motivation in Physical Therapy Through the Lens of Self-Determination Theory: Implications for Game Design

Maria Aufheimer  
Karlsruhe Institute of Technology  
Karlsruhe, Germany  
maria.aufheimer@kit.edu

Kathrin Gerling  
Karlsruhe Institute of Technology  
Karlsruhe, Germany  
kathrin.gerling@kit.edu

T.C. Nicholas Graham  
Queen's University  
Kingston, Ontario, Canada  
nicholas.graham@queensu.ca

Mari Naaris  
KU Leuven  
Bruges, Belgium  
mari.naaris@kuleuven.be

Marco J. Konings  
KU Leuven  
Bruges, Belgium  
marco.konings@kuleuven.be

Elegast Monbaliu  
KU Leuven  
Bruges, Belgium  
elegast.monbaliu@kuleuven.be

Hans Hallez  
KU Leuven  
Leuven, Belgium  
hans.hallez@kuleuven.be

Els Ortibus  
KU Leuven  
Leuven, Belgium  
els.ortibus@uzleuven.be

## ABSTRACT

While it is widely assumed that games can engage patients in therapy through their inherent 'motivational pull', relatively little attention has been paid to what HCI games research can learn from strategies employed by therapists. We address this gap by leveraging Self-Determination Theory (SDT) and its mini-theories Basic Psychological Needs Theory and Organismic Integration Theory as a theoretical lens on physical therapy for children and adolescents. Results from in-depth interviews with twelve therapists show that they carefully adjust sessions to allow patients to experience competence, making more comprehensive adjustments than currently offered by games. Additionally, we highlight how therapists leverage their relationship with patients to support motivation, but struggle to reconcile meaningful experiences of autonomy with therapeutic goals. On this basis, we reflect on implications for researchers and designers who create games for physical therapy, and the potential of SDT to provide a foundation for game design and therapeutic practice.

## CCS CONCEPTS

• **Human-centered computing** → **User studies; HCI theory, concepts and models**; • **Software and its engineering** → **Interactive games**; • **Applied computing** → **Health informatics**.

## KEYWORDS

Games, Motivation, Physical Therapy, Rehabilitation, Self-Determination Theory

## 1 INTRODUCTION

Physical therapy is commonly delivered by therapists who have unique ways of motivating patients, striving to keep patients engaged throughout the process [49]. Among other tasks, therapists introduce relevant exercises, adapt them to suit patient needs and progress, and provide feedback—all of which is crucial for patient motivation [49, 65]. In an effort to provide cost-effective and accessible physical therapy, there is an increasing push to shift the therapeutic process to interactive technology, with games in particular being viewed as an ideal platform to support physical therapy delivery [13]. An assumption that underpins this push is that games have an inherent motivational pull [74] that engages patients, and can increase adherence to therapy [47].

However, despite the long-standing interest of Human-Computer Interaction (HCI) and games research in the design of games for therapy and rehabilitation (e.g., [2, 5, 36]), design processes of games to support physical therapy are seldom underpinned by a comprehensive examination of therapeutic practice, which is a missed opportunity for our research community to learn from how therapists work with patients: many games are designed through the lens of functional outcomes, focusing on the translation of exercises into game mechanics (e.g., [76, 83]). Despite being built in consultation with therapists (e.g., [27, 30]), little account is taken of therapists' practices and how they can inform the design of game-based physical therapy. Games for physical therapy predominantly focus on player performance when choosing how to adapt the exercise to the patient. This typically refers to the adjustment of task difficulty (e.g., [76, 80]), while therapists adopt a much more comprehensive

role in terms of patient motivation. Consequently, the potential that lies in mapping the therapist's role into games for physical therapy remains untapped.

In our work, we address this gap through an empirical analysis of therapeutic practice that seeks to examine the role of the therapist from a holistic perspective. We hope to make therapists' approaches accessible to researchers and designers in our field, broadening the foundation for the design of games for therapy. We adopt the lens of Self-Determination Theory (SDT) [1, 21, 73] as theoretical perspective that allows us to examine in detail how therapists engage with their patients. SDT is a macro-theory of motivation, well-being, and psychological functioning that introduces six mini-theories on specific facets of motivation and functioning. In particular, we leverage the mini-theories Basic Psychological Needs Theory (BPNT) [70, p. 326ff.][22, p. 233ff.] and Organismic Integration Theory (OIT)[73, p. 19, ch. 8]. We chose BPNT as our first focus as it defines three basic psychological needs (i.e., competence, autonomy, and relatedness) as integral to well-being and psychological functioning. Given the inherently extrinsic nature of patients' motivation to partake in physical therapy [37], we selected OIT as our second focus, as it addresses extrinsic motivation and allows us to examine how external factors affect patient motivation. The main research questions that guide our work are the following:

- (RQ1) What strategies do therapists employ to motivate their patients, and how do they adjust therapeutic sessions to suit the needs of individual patients?
- (RQ2) What are differences and similarities between the way therapists approach and work with patients, and the way players are approached in games for therapy?

To address these questions, we carried out semi-structured interviews with twelve therapists. We focused on therapists working with children and adolescents, as this is a target audience already interested in games, and therefore likely to benefit from game-based approaches to physical therapy. We apply Thematic Analysis [3, 11] to analyze our data.

Results show that therapists intuitively apply BPNT in physical therapy: they very carefully tailor sessions to patients in terms of exercise difficulty and feedback delivery, taking into account physical abilities and factors such as patient mood, ensuring that patients are given space to experience competence while avoiding instances of failure at any cost. Yet, while therapists understand that supporting patients' autonomy is relevant to their motivation, we find that many therapists strongly believe that, e.g., offered choices need to be restricted to ensure that therapeutic goals are achieved. We find that therapists strongly rely on a positive relationship with their patients to keep them engaged, an effort which is supported by acts that seek to increase extrinsic motivation (e.g., rewarding). When comparing these findings to strategies that seek to motivate players in games for physical therapy, we find similarities (e.g., feedback provision and adaptation), but also differences. Most notably, therapists adapt and provide feedback at a higher level of fidelity, and completely avoid patient failure, which is not always found in games for physical therapy.

Our work makes the following three contributions: **(1) We provide a comprehensive examination of therapeutic practice**

**through the lens of SDT** [1, 21, 73]. This closes a gap in our understanding of how therapists motivate their patients, and lays the foundation to enable researchers and designers to build on this knowledge in their work. **(2) We compare therapists' approaches to best practices in the design of games for physical therapy, and compile implications for design with respect to how games need to improve to capture the strengths of physical therapy.** Through this, we highlight key lessons for HCI games research. Likewise, we highlight shortcomings of therapeutic practice to identify gaps that could be filled through games. **(3) We reflect on the potential of SDT and its mini-theories in the structured design of therapeutic practice and games for physical therapy,** providing our research community with an example of how SDT can be applied to understand expert practice and leverage it in technology design.

As we shift toward technology-led interactive physical therapy, the question of how interactive technology including games can best support patients needs to be answered. Our work presents a first step toward understanding therapeutic practice more comprehensively, and offers insights that can serve as a step toward theory-driven design and development of adaptive games for physical therapy.

## 2 BACKGROUND

In this section, we give an overview of patient motivation and adaptation in physical therapy, and in the context of digital games. Additionally, we introduce Self-Determination Theory as our theoretical lens, and motivate why we chose this theory as a foundation for our work.

### 2.1 The Role of Motivation and Adaptation in Physical Therapy

Generally, being 'motivated means to be moved to do something' and 'someone who is energized or activated toward an end is considered motivated' [71]. Motivational theories, i.e., psychological theories that are concerned with the *why* of behaviours, address the initiation and direction of behaviours as fundamental elements of motivation [21]. For example, Protection Motivation Theory, first introduced by Rogers and Prentice-Dunn [67], is a prominent theory of motivation in research on physical therapy [12, 32, 33], where it is applied to understand barriers to patient adherence, i.e., patients committing to and following their treatment plan [37].

**The relevance of patient motivation is widely acknowledged in physical therapy because of its interpretation as a precursor to adherence** [18, 37], ultimately leading to improved quality of life [31]. The field has addressed patient motivation through numerous works, with a highly cited literature review by Maclean et al. [49] identifying three perspectives on motivation: first, motivation as a personality trait of patients that is unaffected by extrinsic factors, strictly excluding social and environmental factors; second, motivation and its relationship with extrinsic factors (e.g., internalised cultural norms, the rehabilitation environment, and patients' social support network) as influential to motivation; and third, motivation as a construct influenced by extrinsic and intrinsic factors. The authors emphasise the importance of understanding all factors contributing to motivation in order to empower

rehabilitation professionals to motivate patients to the best of their abilities, thereby supporting engagement and adherence. Another literature review by Grindley and Zizzi [32] paints a similar picture, focusing on adherence behaviour in works from sports medicine, sport psychology, athletic training, and physical therapy. While the authors focus on older adults, the factors they identify as contributing to adherence behaviour appear generally applicable. They identified two categories of contributing factors, namely personal (intrinsic) factors such as self-motivation or pain tolerance, and environmental (extrinsic) factors such as communication or therapist support. Majnemer et al. [50] present similar results based on a study investigating motivational factors in adolescents with cerebral palsy.

Sluijs et al. [78] report, amongst other factors, lack of positive feedback (i.e., a factor contributing to extrinsic motivation) as highly related to patient noncompliance with physical therapy exercises. Similarly, work by Rone-Adams et al. [68] points towards a significant negative impact of caregiver stress as an external factor and compliance with home exercise programs in caregivers of children with disabilities. More recent work by Holt et al. [37] looked to identify and categorise barriers, facilitators, and strategies to boost exercise therapy adherence in a literature review involving work on children and adolescents with musculoskeletal conditions. They identify time constraints, physical environment, and negative exercise experiences as common barriers to adherence, while social support and positive exercise experiences are identified as facilitators, aligning well with the aforementioned research. As for boosting strategies, the authors report that reinforcement, exercise program modification, and education were most often found in the work they reviewed. They conclude with a high-level recommendation to consider efforts to individualise adherence-boosting strategies, as well as making exercise more enjoyable, social, and convenient.

**The literature provides few concrete suggestions for how to best support adaptation (i.e., adjusting therapy to individual patient needs).** Generally, there is a strong focus on adjusting exercises to physical skills. For example, this can be achieved through high-level periodisation, i.e., structuring therapy into phases that increase and decrease in intensity but maintain an overall trend towards progressing in intensity [17]. Working at a higher level of detail, Blanchard and Glasgow [8] contribute a model for exercise progression and regression in rehabilitation, dividing exercises into blocks or sub-components of a skill that are added and removed to change difficulty.

However, despite the broad recognition of the importance of individual and psychological factors affecting patient motivation, we found little work that concretely examined how rehabilitation can be adapted to patients. Most notably, sport science recognizes the emotional toll of injury on elite athletes (e.g., Podlog et al. [59]), and suggests that it needs to be taken into account in rehabilitation. Likewise, there is work from rehabilitation science arguing that factors such as acceptance of one's own disability impact therapeutic outcomes [46], but falling short of concrete recommendations as to how this should be accounted for in therapeutic practice.

## 2.2 Player Motivation and Adaptation in Games for Physical Therapy

Researchers have investigated the use of games for physical therapy for over twenty years [38]. Prior research has explored the application of commercial games, as well as specifically developed games for rehabilitative purposes (e.g., [10, 52, 61]). **Among the most prominently discussed advantages of using games for physical therapy is the assumption that games motivate patients** [9] through unique characteristics that are inherently motivating [43].

Player motivation has been researched extensively: similar to physical therapy linking patient motivation with adherence, games research views player motivation as a precursor to prolonged engagement. Here, 'flow'-theory—a theory of optimal challenge in which a person's skill is well-matched by the difficulty of an activity [19]—is frequently leveraged. Flow theory closely links challenge and motivation: balancing in-game challenge with player skill to achieve an optimal experience is closely linked to entering a state of flow, i.e., losing oneself in an activity. In turn, this is linked with prolonged player engagement and sustained motivation [53].

In consequence, developing mechanisms to match in-game challenge to player skill has become of central interest to games research. Here, research has examined the potential of dynamic difficulty adjustment (DDA) as a means of automatically attuning game difficulty to player skill in real-time based on player performance, e.g., Ang and Mitchell [4], Ben Itzhak et al. [6], and Salisbury et al. [76]. Such approaches have been demonstrated to have positive effects on player motivation [57]. Likewise, **the importance of skill balancing is recognized in the context of games for physical therapy, highlighting the importance of matching in-game challenge with patient motor skill** [25]. To achieve this, calibration routines (i.e., adjusting games to parameters such as player range of motion at the beginning of a session [28]) are leveraged in combination with other forms of difficulty adjustment. To match in-game difficulty with player skill at runtime, DDA algorithms have also been used in games for physical therapy. For example, DDA algorithms have been integrated in movement-based games to support physical therapy among older adults with the goal of improving player motivation [39, 79]. Such algorithms may, for example, consider in-game performance [58] or physical movement data [62] as input factors to adapt difficulty by changing numbers of targets [58] or the size of target areas [62]. Generally, we observe that adaptation in games for physical therapy remains strongly rooted in parameters of player performance.

However, we also want to highlight the existence of **design recommendations that consider the importance of other factors for player motivation in games for physical therapy that extend beyond matching skill and difficulty.** For example, Flores et al. [25] highlight that aspects such as engaging players in meaningful activities and providing appropriate feedback are expected to contribute to motivation. Likewise, Kayali et al. [44] examined how games for health can support long-term player engagement, drawing similar conclusions that highlight the relevance of individual and valuable experiences, the provision of (progress) feedback, and employment of mechanics to continually engage players (e.g., rewards or multiplayer features). This is also reflected in work by

Hernandez et al. [36] showing that it is possible to design fast-paced, action-oriented games for players with motor disabilities. More recent work by Cimolino et al. [16] looking into partial automation of gameplay as an accessibility feature further underlines the importance of matching challenge and player abilities, a consideration that is also supported by Gerling et al. [27] as a means of reducing risk of vulnerability of players. In recognition of the complexity of player motivation and contributing factors, HCI games research has developed a vested interest [82] in Self-Determination Theory [1, 21, 22, 72]. It is the second prominent lens on player motivation, and posits that players engage with games as a means of fulfilling basic human needs [74]. We discuss the theory and its application in games research in more depth in the following section.

### 2.3 Theoretical Lens: Self-Determination Theory

Self-Determination Theory (SDT) is a macro-theory of motivation, well-being, and psychological functioning first introduced by Deci and Ryan [21] in 1985, and has since been continuously improved and advanced. In general, SDT views people as active organisms that evolve and develop depending on social contexts [1, 22, 72]. To date, SDT comprises six mini-theories that more closely examine different aspects of motivation and psychological functioning. In particular, we leverage two mini-theories as lenses for our analysis:

**Basic Psychological Needs Theory (BPNT)** [73, p. 10ff., ch. 10] [70, p. 326ff.] [22, p. 233ff.] argues that at its core, psychological health and well-being flourish in contexts in which autonomy, competence, and relatedness—the three basic psychological needs—are supported. Autonomy refers to a person’s need to have control over their actions and the ability to act out of their own volition or in a way that reflects their interests and values. Competence encompasses the need to feel challenged but also capable of executing a task well. Last, relatedness addresses the sense of belonging and feeling connected to others. What is noteworthy here is that part of this mini-theory—the effects of (not) satisfying one or more of the basic psychological needs—is addressed within each of the other mini-theories in specific contexts.

Second, **Organismic Integration Theory (OIT)** [73, p. 19, ch. 8] addresses a spectrum of extrinsic motivation, whereby extrinsic motivation is described as behaviour executed for the sake of its outcome, e.g., rewards. This mini-theory describes four forms of extrinsic motivation on a continuum of internalisation—with fully internalised behaviour being intrinsically motivated: (1) external regulation, e.g., performing a behaviour to obtain a reward; (2) introjected regulation, e.g., engaging in a behaviour to maintain a feeling of self-worth; (3) identified regulation, e.g. consciously regarding the behaviour as personally important; (4) integrated regulation, e.g., the behaviour fully aligns with one’s beliefs and needs, but is still executed for extrinsic reasons, rather than the sole enjoyment of the task—in contrast to intrinsically motivated behaviour. OIT additionally addresses the concept of amotivation, i.e., the absence of motivation, alongside these motivational regulations. The mini-theory picks up on the basic psychological needs for autonomy and relatedness as facilitators for internalisation and specifically addresses the effects of social contexts on extrinsic motivation.

We chose BPNT as our first focus as it defines three basic psychological needs as integral to well-being and psychological functioning and selected OIT as our second focus, as it allows us to examine how external factors affect patient motivation. The other mini-theories introduced by SDT (and not used in this study) are Cognitive Evaluation Theory (CET) [73, p. 19, ch. 6, 7] (addressing intrinsic motivation), Causality Orientations Theory (COT) [73, p. 20, ch. 9] (investigating motivational orientations), Goal Contents Theory (GCT) [73, p. 21, ch. 11] (linking goals to needs satisfaction), and Relationship Motivation Theory (RMT) [73, p. 21, ch. 12] (focusing on the need for relatedness).

The importance of self-determination and specifically autonomy support has been studied in contexts related to physical therapy: In classroom settings, Reeve [64] found that an autonomy supportive teaching style, e.g., by using non-controlling language or communicating value, overall supports students’ motivation. A review by Ntoumanis and Standage [55] analyzing work on school physical education that employ SDT found needs satisfaction in general and particularly through autonomy supportive teaching techniques to be beneficial. A more narrow investigation of autonomy supportive teaching styles by Cheon et al. [15] further confirmed these results. Similar results were also suggested by Cheon et al. [14] in the context of high-stakes competitive sports, and by Teixeira et al. [81] in a review of studies on leisure time exercise motivation in adults.

An increasing body of work also acknowledges the importance of self-determination in physical therapy, particularly as a means to improve patient adherence and effectiveness of therapy (e.g., [60, 85]). However, while SDT is leveraged to understand functional therapeutic outcomes, few works have specifically adopted SDT as a theoretical lens to investigate aspects of motivation in physical activity. This appears to show a strong focus on needs satisfaction [7, 75] and motivational regulation [63] from the perspective of patient experience. In a survey paper focusing on motivation in pediatric motor rehabilitation, Meyns et al. [52] show that motivation is rarely included as an outcome measure, and authors report a strong bias towards the use of new technologies in interventions that mention patient motivation. However, Meyns et al. [52] argue that **the integration of SDT remains shallow, repeating the argument that games have an inherent motivational pull [74], but failing to answer which specific practices affect patient motivation and how they do so.**

Interestingly, the use of SDT is criticized from a similar perspective within the games research community. While the role of needs satisfaction is acknowledged and investigated in games, Deterding [24] points out the importance of the (social) context in which a game is played when investigating autonomy support. Further, a most recent literature review by Tyack and Mekler [82] highlights the prominence of BPNT in particular at surface level (e.g., over half of the included works in their review utilise at least one SDT-based measure in the context of player experience, i.e., the Intrinsic Motivation Inventory [74] or the Player Experience Needs Satisfaction scale [74]), but also criticizes that games research rarely considers other mini-theories or details of SDT concepts as theoretical frameworks. This is mirrored in the design of games for physical therapy, where SDT has only been superficially applied (e.g., [20, 48, 51]), leaving the full potential of SDT as a theory that can help explain motivation and well-being untapped.

Taking into account the importance of patient motivation in physical therapy, we consider this a missed opportunity for game design: Self-Determination Theory has shown promise both in games research and in rehabilitation science, and can be leveraged to close the gap in our understanding of how therapists motivate patients, and how these efforts can be translated into the design of games for physical therapy.

### 3 METHODOLOGY

We carried out semi-structured interviews with rehabilitation professionals in order to explore practical approaches to patient motivation in traditional physical therapy, leveraging the lens of Self-Determination Theory [1, 21, 22, 72]. We sought to answer our two research questions: **(RQ1)** What strategies do therapists employ to motivate their patients, and how do they adjust therapeutic sessions to suit the needs of individual patients? **(RQ2)** What are differences and similarities between the way therapists approach and work with patients, and the way players are approached in games for therapy? Thereby, we hope to derive insights into traditional physical therapy that can be leveraged within the HCI games research community to inform the design of games for therapy.

#### 3.1 Interview Questions

We grounded our guiding questions for the semi-structured interviews in a relevant subset of the mini-theories of SDT [1, 21, 22, 72], specifically the Basic Psychological Needs Theory (BPNT) [70, p. 326ff.][22, p. 233ff.] and Organismic Integration Theory (OIT) [73, p. 19, ch. 8]. We focus on these mini-theories because BPNT offers a comparably universal lens and appears to be the most prominently applied mini-theory in games research [82]. As patients are inherently extrinsically motivated to partake in physical therapy, we argue that OIT offers an interesting additional theoretical lens to examine how the therapist and therapeutic practice shape patient motivation.

Figure 1 gives an overview of the mapping between SDT as theoretical background and keywords for the definition of questions. We base our keywords (and therefore questions) addressing BPNT and OIT on a general reading of the theory as provided by Deci and Ryan [22] [70, 72, 73]. Regarding BPNT specifically, we drew keywords from the relevant concepts of the Player Experience of Needs Satisfaction (PENS) [74] questionnaire, a validated [40] and widely adopted measure. While the PENS was originally developed to support the evaluation of digital games, the way that the core constructs of BPNT are approached makes it a suitable resource to inform question design for our interviews. Note that the PENS questionnaire further includes the concepts of presence/immersion and intuitive control, which we omitted as they are specifically framed towards digital games. Our approach in deriving keywords differed for Organismic Integration Theory (OIT), which addresses extrinsic motivation: we were not able to select a suitable scale, with the GAMS questionnaire [45] very specifically addressing games and therefore not adequately capturing the context of physical therapy. Hence, we utilised the OIT's taxonomy of regulatory styles by Ryan and Deci [73, p. 192][82, p. 3] as a basis to achieve a similar segmentation as a scale would have offered.

The questions were formulated in three iterations. Initially, two of the authors drafted questions and prompts separately. These drafts were then discussed, compared with the mini-theories, and merged by the two authors, resulting in the second version. This was then shared with two colleagues in rehabilitation science, and questions were adjusted based on their remarks.

The final interview guide includes eleven questions of which seven address each of the concepts within BPNT and OIT. For example, **'Question:** *Can patients influence the structure of therapy? For example, can they choose which exercises they want to do, choose from set of alternatives, or the order of exercises? Can they choose level of difficulty? Are there other aspects of therapy where they get choice?* **Prompts:** *What do you do if they don't want to do a specific exercise? Do you think there are benefits / drawbacks to giving them choice?*', addresses autonomy support within BPNT through giving choice.

The full set of questions is included in the supplementary materials. Note that questions were developed in English, and then translated into Dutch as the interviews were conducted in Belgium. All questions were checked by proficient speakers with backgrounds in games research and rehabilitation science.

#### 3.2 Participants and Procedure

We recruited twelve physical therapists through existing project networks and personal contacts. All participants work with children and adolescents; most also work with babies and very young children (P02, P03, P05, P06, P08, P09, P11, P12), and/or adults (P01, P02, P03, P07, P09, P11, P12). Most of the participants work with people with different disabilities. Two exclusively work with people with Cerebral Palsy, a group of neurodevelopmental disorders involving various functions (e.g., sensory function or musculoskeletal function) [69], (P02, P04). Three participants focus on working with people with what they consider to be *'severe motor impairments'* (P01, P04, P09); one participant works with *'minor to moderate impairments only'* (P06), while all others target any level of severity. There were different views on games among the participants: while perspectives were generally positive, only a few integrated them in therapeutic practice (e.g., as rewards); the majority of participants did not use games as part of physical therapy. A table detailing participant information can be found in the supplementary materials.

Participant invitations were sent out via e-mail, including an information letter and informed consent form. Potential participants were asked to read both documents, reach out in case of questions, and return the signed informed consent form via e-mail, indicating their preferred interview language (either Dutch or English) and their preferred video call software, with all interviews being carried out remotely. At the start of each call, participants were asked again if they had any questions before the audio recording was started. Once the recording started, the interviewer went through the key points of the informed consent form to ensure understanding and consent before starting with the semi-structured interview. After the interview concluded, participants were sent an e-mail thanking them for their participation, to arrange remuneration and to enquire whether they would like to be informed about the outcome of the study. Interviews lasted about 45 minutes, and participants were offered 20€ as a reimbursement for their time. The research

Basic Psychological Needs Theory	competence	felt competent / capable; abilities matched challenges
	autonomy	interesting options / choices; did interesting things; experienced freedom
	relatedness	formed fulfilling / important relationships
Organismic Integration Theory	amotivation	not being motivated
	external regulation	obtain reward; avoid punishment
	introjected regulation	avoid guilt / shame; get feeling of self-worth / approval
	identified regulation	personally endorsed values, goals, needs
	integrated regulation	conscious value of importance

**Figure 1: Mapping between SDT mini-theories, encompassed concepts, and keywords used to derive interview questions.**

protocol was approved by the KU Leuven social and societal ethics committee.

### 3.3 Positionality

When leveraging reflexive research approaches[3, 11], it is important to acknowledge the impact of our own backgrounds and positionality on our work. Generally, our research team has been active in the human-computer interaction and rehabilitation science research communities for many years, with many of us having previous experience in designing (playful) assistive technology. The main author has a background in computer science and media design/HCI. They do not have considerable personal experience with physical therapy, and are not a parent. However, they continuously work on their ally-ship by consciously seeking out media designed, written, or recorded by members of marginalised groups in order to sensitise themselves to the obstacles members of these groups face in everyday life. The other authors of this paper are trained in computer science, rehabilitation science, and the social sciences. Two members of the research team have previously developed game-based interventions to support physical therapy; three further members of the research team have practical experience of working as therapists. Additionally, some members of the research team have experience with physical therapy from the perspective of the patient, and/or are parents of children who are currently in physical therapy to support their motor skills. As such, we also have personal experience of instances of (a)motivation in the context of physical therapy. However, we want to point out that these experiences should not be compared to the lived experience of young people engaged in long-term physical therapy. Finally, there also is a breadth of perspectives on what games can and should provide in the context of rehabilitation (e.g., whether the technology is fit for comprehensive deployment) within our team, and we have different views on the role of the therapist (e.g., whether they lead through physical therapy, or act as coach supporting the patient).

### 3.4 Analysis

Data were analyzed following deductive reflexive Thematic Analysis [11, p. 10, 55–57][3]. TA in general describes a group of methodological approaches to develop patterns of meaning across qualitative datasets through a rigorous process of data familiarisation, coding, and theme development. While all TA approaches offer some theoretical flexibility, i.e., being applicable to a range of different research questions and circumstances, individual approaches may vary greatly in their underlying philosophy and proposed procedures. *Reflexive* TA in particular is characterised by highlighting the single analysing researcher’s inherent subjectivity as an essential part of the method, as well as its reflexive and recursive process. Discussions and coding with other researchers are not excluded in this approach, but rather considered as an optional measure. A *deductive* (reflexive) TA is shaped by the use of, for example, existing theoretical concepts as a lens through which data is coded.

As a first step, all interviews were transcribed, translated from Dutch into English (with the support of DeepL [23] and native-level speakers of both languages), and potentially identifying information was removed.

In a second step, the first author conducted a deductive reflexive Thematic Analysis, following the widely adopted approach introduced by Braun and Clarke [11, p. 10, 55–57][3]. Already familiar with the data through the process of transcribing and translating the interviews, the first author engaged in an iterative coding process, addressing the relevant constructs. The initial assignment was then reviewed in another iteration: the first author, who also conducted the analysis thus far, checked their own assignment in a horizontal approach, i.e., going through all assigned quotes per theme, reflecting on the assigned quotes’ adequacy, adapting the coding where necessary. Finally, the quotes per theme were grouped into codes reflecting a common message among each group of quotes. The codes within each theme were regularly discussed within the research team to evaluate the progress of the analysis and gather points of view for the discussion, supporting the overall analysis, but leaving responsibility for the process with the first author.

## 4 RESULTS

In this section, we present the results structured around the two mini-theories of Self-Determination Theory [1, 21, 22, 72] leveraged during analysis. We begin with Basic Psychological Needs Theory (BPNT) [70, p. 326ff.][22, p. 233ff.] as the most common mini-theory in HCI games research [82], and then present Organismic Integration Theory (OIT) [73, p. 19, ch. 8], which specifically examines extrinsic motivation, an aspect highly relevant in therapeutic settings where patient motivation may hinge on external factors. For readability, we refer to the participants of our study as ‘therapists’ and to the people attending physical therapy sessions with them as ‘children’<sup>1</sup>.

### 4.1 Basic Psychological Needs Theory

We structure the results around the three main basic psychological needs within BPNT, *competence*, *autonomy*, and *relatedness* (see Section 2.3).

**Competence** [73, p. 127ff., ch. 10]. Our results show that all **therapists intuitively embraced the relevance of experiencing success—or competence—in the context of physical therapy**. This theme encompasses two main areas: (1) the careful design of physical therapy sessions and within it the adaptation of the difficulty of exercises to meet the skill level of the children and facilitate the experience of competence; and (2) the provision of feedback to reinforce perceived competence.

The overall therapeutic process is determined by initial and regularly repeated assessments of children’s abilities (e.g., through standardised tests) and the goals of the physical therapy set by caregivers, therapists, and sometimes the children themselves. In designing therapeutic sessions, therapists engage in a continuous cycle of monitoring a child’s performance and adapting the exercises accordingly, starting with initial appraisal of the child’s abilities. To engender the experience of competence, several therapists pointed out the importance of **building off existing skills in physical therapy sessions**, e.g., ‘You put someone on the mat and you look at what they already do by themselves. Uhm... so if they can already do things by themselves, those are things that you can ask for more...’ (P02). Then, therapists **work in small increments regarding goals and difficulty**, e.g., ‘Well, that’s- we’re often going to divide the goals into smaller goals and if we still feel that it’s harder, we’re going to divide it into even smaller steps [...]’ (P09), and also **vary exercises to adjust difficulty**, e.g., ‘So I try to bring a degree of variation in the exercises, that they are different and that I test the same thing, but that it’s a little less difficult [...]’ (P03).

In terms of **determining when to adjust difficulty**, many therapists reported **relying on their personal intuition and experience with a given child** to adjust difficulty, e.g., ‘Through the experience you know, this child... with these possibilities of transfer and manner of moving that I can ask and- and here I can build on this I know where I am starting from and where I can go to.’ (P06). However, there were also practical indicators that some therapists leveraged, including **task completion times, changes in performance and quality of exercise execution, and engagement**,

with one therapist pointing out that ‘[...] [adjusting difficulty] is hard. Uh, because [difficulty] can’t always be adjusted in small enough increments.’ (P07).

Therapists also underlined the importance of adjusting difficulty to **avoid frustration, being mindful of children’s emotional experience of physical therapy**, e.g., ‘[...] there are young people who can try the same thing 30 times and who totally... don’t mind at all that they don’t succeed and only succeed at the 31st time. But there are also young people who are already frustrated after three attempts... um... so yes, it really depends on the individual. So I think that the emotional is more important than the quantity.’ (P01). This emotional component was also taken into account when communicating difficulty adjustments to the children. Here, most therapists agreed that they either **don’t communicate a decrease in difficulty to the children or communicate a decrease in difficulty in a very casual way**, e.g., ‘Making it easier is not always what you communicate. Because that is sometimes very confrontational, like “you can’t do this, so I’m going to make it easier”.’ (P01). In contrast, there was **no consensus whether an increase in difficulty should be communicated**. Here, one therapist suggested that ‘[...] sometimes that can bring extra stress that shouldn’t be there’ (P07), while others considered it an opportunity to reinforce perceived competence.

The **potential of feedback to reinforce perceived competence** was also leveraged widely. Many therapists reported offering immediate **verbal encouragement and praise**, e.g., ‘Of course there’s always verbal feedback too, hey, the more positive the better um...’ (P04) or ‘[I use] coaching, like, “oh that’s really good and you[re] doing this and now we’re gonna try”.’ (P11). Additionally many therapists complemented this approach with **showing the children their progress by keeping track of performance over the course of multiple physical therapy sessions**, e.g., ‘[...] I always write [it] down, they know in two months I will really examine it and- and try to see how it’s going now and to motivate and show “oh we have progress”, also with the parents [stammering] after every- after every session I- I see it, I see progress or not.’ (P12), and **showing their skills or progress to someone else**. Likewise, these records were also used to **offer context if there was lack of progress**, with one therapist commenting that they don’t just ‘say there is no progress, [...] because... we didn’t do [the] exercise or it’s just the weather or you were sick or- that we- that they understand “OK, it’s OK to... [not] have progress every time, it can be just stable and then we see progress [again]”.’ (P12).

**Autonomy** [73, p. 129ff., ch. 10][70]. In the context of physical therapy, our data shows that **autonomy support is a relevant concept, but also a source of tension**. While therapists recognise the importance of giving choice and the connection with children’s motivation, they also perceive that facilitating **children’s autonomy is a trade-off between delivering effective physical therapy and sacrificing their own position of authority and control**. Most therapists defaulted to a strategy where they would limit children’s choices with respect to therapeutically relevant aspects, while offering superficial choice in other areas of physical therapy in an effort to compensate.

Most therapists agreed that **giving choice is not always possible or desirable when it comes to core aspects of physical therapy**, including the selection and adjustment of exercises. For

<sup>1</sup>Therapists used a number of terms to refer to their patients during the interviews, most commonly ‘clients’, ‘children’, and ‘patients’.

example, one therapist commented that allowing children to choose exercises is not possible *[...] unless that you have really mentally very good, uh... kids who can make that choice as well, uhm, but even then it's very, uh, important that the therapist also limits those choices and steers them in the right direction to, uh, still be functional-ah, not, functional- to still be constructive.* (P07). Likewise, another therapist commented that the adjustment of exercise difficulty was also therapist-led *[...] because that's really a therapeutic part of what we do... uhm... yes... The therapeutic part is working on the right level, so no, they don't really have much say in that.* (P01). In fact, some therapists almost experienced offering choice as a struggle for control over the session with the child that would have long-term implications, e.g., *[...] sometimes I've had that with autistic children and there you have that problem because, every time I put them there again, or try to correct them, yes, they would become hysterical and that is quite a problem then you just have to let them practice the way they actually want to. And that's a struggle because you want to do your therapy well, don't you, in the long run, you can't say every time "we're not going to do it today either".*(P03).

Instead, the majority of therapists sought to **give an illusion of choice to achieve motivational goals**, where control ultimately remained with the therapist. This was reflected in therapists' statements, e.g., *[...] it's good that they [children] can determine it a little bit, because that also gives them a little bit of a feeling that they're... that they're doing something and they want to do, eh.* (P02). With respect to specific areas in which they allowed choice, therapists reported *[...] leaving a choice, for example, between two exercises [...]—they are both targeting the same thing but the child has the feeling that they can choose an exercise.* (P09), awarding choice in the subsequent activity, e.g., *'Then you say "okay, 10 pearls you're going to string and then [...] we can do something else"'* (P08), or *[...] if they have worked well they can [...] choose a sticker or they can choose a candy.* (P03).

There were only a few instances where therapists reported following a **patient-led approach, giving choice in the specifics of exercises or the structure of physical therapy**, e.g., *'there are also children [...] who prefer to discover something from their own experience. [...] and then I let them discover for themselves [laughs] [...] and if [...] I see that they are interested in a certain object then... then I'll go via that [...] object [to] try to arouse their interest.'* (P08). An important factor in deciding whether to make accommodations when therapists would prefer not to do so was **the emotional or physical state of children**, e.g., *'I think listening to what those people have to say, I think that's important. If they are in pain, they are in pain and you have to take that into account, I think that's important. [...] And trying to adapt your exercises in terms of intensity and in terms of quantity so that they don't always have this pain during your therapy because that's not nice, is it, you don't like it yourself when we do that.'* (P03).

In cases where no choice is possible, therapists appear to **leverage their relationship with the child to balance the lack of choice**, e.g., *'yes, friendly, a friendly way, it is so that you are still therapist ... [...] We [the therapists] decide what we're going to do or what we're going to do together... and we also decide - within the exercises... what they're going to focus on. [...] But it is more pleasant if it can be somewhat friendly.'* (P02). We discuss this aspect further

in the following section that examines *relatedness* in the context of physical therapy.

**Relatedness** [73, p. 165ff., ch. 10][70]. Relatedness is the most prominent theme derived from BPNT within our data, with the relationship between therapist and child unanimously being regarded as an element central to effective delivery of physical therapy. Indeed, therapists agree on the **importance of a good relationship with the children**, for example stating that *'[...] it's important that you really know these kids. Uh, to, uh, to be able to respond to... uh, their performance, [...] what they can and what they can't do.'* (P07), with some also pointing out that it is so fundamental that they **only continue to work with a child if there is a good connection**, e.g., *'It also happens very, very rarely that there is no- yes, that there is no click between therapist and patient or- or vice versa and then it could happen that a client goes to another therapist. [...] We are now going to pass on this collaboration to their colleague because we are not achieving what we want to achieve, because the therapeutic bond is not what it should be.'* (P01).

When first establishing their relationship with a child, therapists report **respect, openness, honesty, and patience** to be key factors, e.g., *'I think you should be very open to those children. Uh, that they can... come to you with other things too.'* (P07), *'And also very important, have patience, a lot of patience. That's a tough one. Well, that's important in itself, otherwise you get crazy with things.'* (P10). Therapists made it clear that their approach and possibilities of fostering a relationship **depends on the individual**, e.g., *'Uhm... Well, character, character, culture sometimes also... yes... there are young people where I... try to adapt somewhat to their culture or their... possibilities.'* (P01). It is also **influenced by the specifics of the physical therapy** they offer, such as the context in which it takes place (e.g., boarding school vs. private practice), frequency of appointments and contact with the child, and the specific type of therapy (e.g., occupational vs. physical).

In most cases, therapists seem to focus on **friendly and casual behaviour while maintaining professional distance**, e.g., *'yes, friendly, a friendly way, it is so that you are still therapist uhm... [...] So then... they always have a sense of "okay, that's the therapist and I'm the client"'* (P02). To further foster and deepen the relationships, therapists in our study report to **making an effort to continuously communicate with the children throughout physical therapy**, e.g., *'Or... For example, I have a child with whom we are learning to ride Adremo [a head-foot wheelchair steering system] and he always hurts his foot quickly. But he understands when I say, um, "you're building up a lot of tension and I understand that your foot hurts but now we're going to ride until a certain point that we then agree to ride together and then I'll ride a bit with you and then you go again..."'* (P05). This was often complemented by **offering physical interactions and support during exercises**, e.g., *'[...] and if I see that they are having a hard time, I also go and support them manually or I do the exercise with them that they have the feeling that they are doing together with two that they are not always alone.'* (P03).

Some therapists also leveraged regular provision of **rewards as a way to establish a good relationship**, for example, *'[...] with the reward I try to work a little bit too, they get stickers or they get to choose something, choose a candy. Which for a child,*

*with some children can build a really good relationship with that because they know they're going to get something like that.'* (P03). Overall, we also want to note that therapists were so invested in maintaining a positive atmosphere throughout physical therapy that they reported actively avoiding situations in which they would need to give negative feedback to a child.

On a general level, therapists were highly invested in maintaining a positive relationship with the children because of the ubiquitous view that **establishing a feeling of trust and safety builds the foundation for effective physical therapy**. For example—and among many others—one therapist commented that *'[...] trust is very important [...] if they [...] can tell that they don't like something. Or that they do like something, it's only going to benefit their therapy. And for that you need a little bit of trust always.'* (P02).

## 4.2 Organismic Integration Theory

We structure our results around the forms of extrinsic motivation described within OIT (see Section 2.3), starting with the absence of motivation, and progressing through the different forms of extrinsic motivation.

**Amotivation** [73, p. 189ff.] While this theme was touched upon by therapists, only few reported incidents in which they could not manage amotivation within their practice. This supports the notion that amotivation requires therapist attention, but is generally manageable within physical therapy. For example, therapists pointed out that while **amotivation does occur** from time to time, it can easily be managed because *'[children] really don't need too much pressure because they just need to experience that they can do something themselves'* (P04) and that *'they usually like it so much [...] you actually don't always have to go out and motivate a lot'* (P07), essentially saying that **children either see and understand the value of, or simply enjoy their physical therapy sessions**. The latter further relates to statements **connecting amotivation and cognitive ability**, saying for example that *'the ones who have a harder time staying motivated to really stay in therapy or something, are the ones who are cognitively stronger.'* (P08).

The **importance of taking amotivation seriously** was noted by therapists, e.g., *'[...] if a child is really not motivated then you won't achieve anything. I think intrinsic motivation to make the child work is very important, that's what therapy is all about.'* (P06). Therapists drew from **various mitigation strategies**, such as **resolving the cause through conversation with the child**, or in some cases, more comprehensive adjustments to the physical therapy plan. Here, therapists mentioned switching back and forth between skills (e.g., alternating exercises focusing on fine and gross motor skills), or substituting exercises that would each address the same goal. Additionally, therapists indicated **leveraging their relationship with the children** to address amotivation, e.g., *'[...] sometimes it happens that I first talk to them and ask, "hey, how is school today?" You ask those things first anyway and then you actually start the program the way you would like it [...]'* (P03) and **the use of incentives or rewards**, e.g., *'If they have worked well they can choose a reward at the end [...]. That also often helps if they really don't want to come [...]'* (P03).

In rare situations, therapists **decided not to address amotivation through any of their established strategies**. Here, therapists were cautious to weigh acceptable reasons for missing sessions against the risk of breaking habit, with one therapist commenting that *'that's an option for once or twice but that's not the same option all days, is it. [...] Those children are fast, eh, when they see that if they come in and say "I don't feel like it" and they don't have to do anything, then they're going to come in every time and not feel like it, eh.'* (P10).

**External regulation** [73, p. 184ff.] Our analysis paints a heterogeneous picture in regards to this theme, showing a wide variety of approaches and perspectives towards the use of rewards, while punishment was rarely used. Generally, we observed two approaches toward the provision of rewards. A number of therapists **reward with fun activities at the end of the session or between tasks**, saying, for example, that *'[...] in the last two minutes we do a game or so [...]'* (P01). Other therapists relied on providing **reward through benefits outside of physical therapy, e.g., at home or with little gifts**. For example, one therapist described how *'[...] at home [children] may sit at the computer, for example, half an hour, if they have worked well [...]'* (P03), or *'[...] if they have worked well they can [...] choose a sticker or they can choose a candy.'* (P03)—with stickers or candy being the tangible reward that was mentioned most often. Additionally, there were also statements that suggested **less tangible rewards that required investment on behalf of the therapist**, e.g., *'super hard enthusiasm, uh, standing around jumping with happiness that he did something right. [...] but especially [showing them that you are] proud.'* (P07).

Overall, **therapists varied their approach to external regulation depending on the child**, e.g., *'it's difficult to say that beforehand but you notice it quite soon as you start therapy that if they are really focused on uhm... yeah rewards from the parents or really focused on, uhm, "did I do it correctly?", "is it [correct] or not correct?"'* (P11). While some therapists clearly emphasise the benefits of rewards over punishment by saying, for example, *'[...] that rewarding and positive work is better than punishment'* (P01), others suggest a rarely occurring **situational need for punishment**, such as withholding rewards, telling off, or spatial separation, most often in response to significant misbehaviour: *'[takes deep breath] Yes... I have already done that. I know for sure that I've already put children in the corner because they really didn't want to cooperate and they behaved very aggressively and then... you have to do something with that, eh.'* (P03).

**Introjected regulation** [73, p. 184ff.] Our data shows that therapists implicitly assumed a role in which they moderated this process through two main strategies: first, sometimes **therapists attempted to adapt situations so that children would not experience negative emotions**, an effort closely related to maintaining perceived competence. For example, therapists reported adjusting exercises or initially neglecting therapeutic goals, e.g., *'it doesn't really matter in the beginning because first it's important for the child to really understand every aspect of the exercise which is quite difficult to get right immediately so... you tolerate quite a little bit in the beginning and you give a lot of success and then you try and tweak it as much as you can to get to the point where it's, uh, as you want it's so definitely the latter.'* (P11).

Additionally, therapists were concerned about instances in which children might have negative experiences because of needs associated with their disability, and adjusted their behaviour, e.g., ‘[...] Now and then to reposition them. And actually also when you do then, well, never show that you, “gosh, do I have to move you again?” So always show that you like doing it, that it’s for them. So... You have to sympathize with them a little bit too, huh.’ (P10).

Further, therapists reported trying to enable children to experience **positive feedback from outside of physical therapy, mostly through demonstrating new skills and progress to family members**, e.g., ‘[...] you know what I also do sometimes when they can do something new [...] I film it and then I send that to the mom and dad, and then they show that to grandma and grandpa, and then they’re, uh- everyone’s happy. That’s important too.’ (P10).

Second, **some therapists attempt to reinforce negative emotions in situations that they deemed appropriate in order to achieve compliance through elicitation of feelings of shame in reaction to misbehaviour of children**, saying for example ‘[...] yes... I could sometimes blurt it out and- and say that I didn’t like the fact that they weren’t- or weren’t nice, [...] and yes... don’t give a reward then. [...] [A]nd sometimes also discuss it with the parents, [...] I had to do that in between with certain children and agree that they should not get a reward at home, because you don’t have much leverage [during the therapy session], eh, if they don’t want to...’ (P03). However, such reports were very few, and for the most part mentioned in the context of what therapists considered severe misbehaviour.

**Identified regulation** [73, p. 187ff.] Here, many therapists report that they make an effort to **explain the importance and potential benefits of physical therapy**, ‘Why it’s important and- and sometimes you have to explain that 3 times, and- and sometimes you have to document that really well, because [...] just saying it’s important to stretch, that’s also not enough, you really have to explain well how muscles work, how muscles grow, how bones grow, uhm... and- and how that comes into imbalance because certain muscles are weak because of a brain injury and- and therefore the other- those muscles need to be stretched. You have to explain that really well and then they understand the importance of it.’ (P06), and **draw the connection to the everyday life application** to further support this effort (e.g., ‘[...] and then it’s easy to put that into therapy, you know, you do a few exercises and you tell them about how it relates their goals’ (P11)). In this context, **independence is most often mentioned as a tangible benefit** for which children should strive, and the **most prominent goal** from therapists’ point of view: ‘[...] the main goal there is [...] that the child can be independent so, uh, that he can change his clothes, that he can just drink a bottle of water so, uhm, it’s really things that he could do in- in daily life [...] yeah, also do the daily activities that they can be independent of the parents or anything else they- they do.’ (P12). However, how well this approach works may depend on factors such as cognitive abilities and age: ‘Gosh, that again is totally dependent on the cognitive [ability] as well, eh, and the age, because they don’t all understand, eh.’ (P10).

Therapists also mention **drawing in other professionals in the expectation that the children will consider them authorities**, such as doctors or psychologists, in what seems to be a holistic approach to support the conscious understanding of a child. For

example, one therapist mentioned that ‘[...] there are also children who are tired of therapy and don’t want to come anymore. Then you really need to have a good talk with them, possibly take them to the doctor. The doctor should explain that it is necessary and important. [...] Because then- they feel that when we hear from the doctor one more time, then that- yes, the physiotherapist also means it because the doctor says the same thing.’ (P10)). However, therapists also pointed out that in their view, **many children have a limited understanding of the importance of physical therapy**, e.g., ‘[...] a lot of kids don’t really understand [...] what therapy they have to use and why that therapy is useful.’ (P03), instead focusing on conveying the importance to parents and other caregivers.

In some instances, therapists report **mitigating the lack of understanding through fun and enjoyment**, with others stating that **understanding is usually not necessary**: ‘they usually don’t need that explanation, they just participate for 25 minutes and they often like that.’ (P09).

**Integrated regulation** [73, p. 188ff.] We observed two different kinds of goals: **overarching goals that also reflect personal values (such as independence), and smaller goals with respect to progress within physical therapy**. For example, one therapist commented that ‘I always try to make [...] some goal oriented therapy, like [...] where do we want to be in 10 sessions and then it’s really depending on the child which goals you pick. I mean for [...] the [hesitates] normal children it might be really functional goals while for DCD children it might be just something really small.’ (P11). Here, it is important to understand that goals are often set or instilled by other stakeholders without consulting the children, limiting the opportunity to achieve integrated regulation. In our data, there were frequent accounts of **networks of external stakeholders setting goals without involvement of the children**, e.g., ‘[...] so usually that’s a little bit of a network that surrounds [...] the class—occupational therapist, speech therapist, kinesiologist—everybody’s sitting there, so to speak—and goals are then set.’ (P02).

When asked about children’s goals, therapists made statements that relate to **independence as an important personal goal in the context of everyday life**: ‘For example, say if they really want to be able to dress themselves and they cannot do it then we will look for tools or solutions to teach them...’ (P08) or ‘Most of the goals that they themselves come up with, um, are things in the area of self-reliance um... “I want to be able to make my own bed because now my brother has to do it for me and then we always fight.” Uhm... “I want to be able to make my own sandwich.”’ (P01). Here, some therapists mentioned that they need to be careful to **support realistic goals and expectations** for those children who do voice their own aspirations, e.g., ‘[...] children who are mentally better, who then want, gosh, yes, something of sport, want to play soccer, want to work with a ball, you see? But yes they sometimes can’t do that at all, eh. [...] Well, yes, so we do try, they always have a goal, eh. [...]’ (P10).

## 5 DISCUSSION

In our work, we have explored how therapists engage with children in physical therapy through the lens of Self-Determination Theory [1, 21, 22, 72]. In this section, we first summarize our work by providing answers to our research questions. Then, we reflect

on implications of our findings for the design of games for therapy, as well as for therapeutic practice.

### 5.1 (RQ1) What strategies do therapists employ to motivate their patients, and how do they adjust therapeutic sessions to suit the needs of individual patients?

Our results show that therapists are acutely aware of the importance of patient motivation for successful therapy, and that they intuitively employ numerous strategies to help maintain it. Many of these align with concepts of Self-Determination Theory, and are shaped by the constraints that therapists experience: viewed through the lens of BPNT, our findings suggest that therapists recognize that offering autonomy over the therapeutic process (e.g., free choice of exercises) could motivate patients, but also creates a conflict with their role as orchestrators of and medical experts within therapy. Therefore, autonomy is supported through strategies that introduce choice in less relevant areas of therapy, e.g., a choice between two exercises that achieve the same goal, or a choice of reward (e.g., a sticker) at the end of a therapy session. Therapists support the need for competence through session structure and adjustment of exercise difficulty to patient needs, again relying on past experience with a person (e.g., starting with exercises they know a patient can complete, and then transitioning to something more challenging), and their own intuition. Similarly, they employ strategies that enhance the perception of competence, e.g., by verbally highlighting successes, and keeping track of patient progression across therapy sessions. Finally, therapists draw strongly on relatedness to motivate their patients, making extensive efforts to establish a positive bond that they continue to leverage throughout therapy. Overall, our analysis reveals a setting in which therapists intentionally restrict patient autonomy, and seek to compensate for this through extensive support for the experience of competence and relatedness. When applying the lens of OIT, this impression is reinforced. We observed heavy reliance on extrinsic motivation, i.e., a predominant focus on external and introjected regulation through rewards and external feedback. The current structure of therapy offers limited opportunity to scaffold toward intrinsically motivated participation in therapy, as for example patients are rarely involved in goal-setting processes that would form a foundation for achieving integrated regulation, an important precursor to the achievement of full intrinsic motivation.

### 5.2 (RQ2) What are differences and similarities between the way therapists approach and work with patients, and the way players are approached in games for therapy?

Our findings show that therapists approach patient motivation and adaptation of therapy from a more holistic perspective than games for therapy, which predominantly focus on adaptation through the lens of matching player skill and game difficulty (see Section 2.2). Although this was also highly relevant in traditional therapy, our results show how the basis for adjustments was broader, with therapists also taking into account in situ factors such as the mood of the patient, their physical condition on the day (e.g., when patients

experienced chronic pain), and whether they had already engaged in comparable activities earlier (e.g., when in school). Here, therapists' testimonies suggest that their approaches toward adaptation achieved a much higher level of fidelity than what is typically provided by games. With respect to further differences, our data show how therapists recognized the individual and sometimes vulnerable situations of their patients, which was also reflected in how they approached therapeutic sessions. For example, there was a strong tendency to avoid negative feedback and support perceived competence at all cost, which is in contrast with best practices in game design, where negative feedback (e.g., making explicit that the player failed to complete a certain task) and penalties (e.g., score reductions, loss of lives, or even ending play) are common. In this context, we also want to highlight the role of trust between therapist and patient, with therapists highlighting that patients would need to trust them with their bodies and physical well-being, an aspect that is rarely considered in the context of game design. In terms of similarities, our findings show that many therapists leverage feedback in similar ways to games, encouraging patients particularly when pushing through more challenging parts of therapy. Additionally, we were surprised by the extent to which therapists integrated individual patient progress over time into their feedback, mirroring the way that many games map player progression (e.g., statistics about player performance across sessions as provided by many online games). Finally, while games generally value autonomy as a pathway to positive player experiences [74], this is less pronounced in the design of games for therapy, where players are commonly expected to adhere to strict protocols [41], which reflects what we observed in our data. In the following section, we discuss the implications for design that we draw from these findings in more detail.

### 5.3 Leveraging Therapeutic Practice to Inform the Design of Games for Physical Therapy

Our work holds nuanced implications for the design of games for physical therapy, both in terms of drawing from strengths and by addressing weaknesses of traditional approaches. Here, we highlight the four key lessons that can be learned from our work: (1) the development of a more holistic perspective on adaptation in games for physical therapy, (2) viewing player performance through the lens of vulnerability, (3) games as an opportunity to increase patient self-determination, and (4) recognizing the limitations of game-based physical therapy and the unique value of human-led approaches. Table 1 gives an overview and brief summary of the detailed recommendations.

First, **game design needs to broaden the perspective on adaptation in games for physical therapy to include factors beyond player performance, extending to situational factors and individual traits of patients (Lesson 1)**. As suggested by previous work, some situational factors such as player mood could be captured by physiological measures [41]. However, this comes with the burden of wearing sensors, which are known to not work well for disabled bodies [42], and needs to be examined from an ethical perspective particularly when working with players who may not understand the purpose of such devices. Instead, we recommend further exploring manual approaches such as suggested

by Frommel et al. [26]. Additionally, our findings imply the need for more comprehensive initial set-up and calibration routines, moving beyond functional patient abilities.

Second, **game design needs to view player performance through the lens of vulnerability, carefully supporting perceived competence while avoiding discouraging feedback (Lesson 2)**. Here, games researchers and designers need to understand that physical therapy inherently focuses on tasks that are challenging for patients, putting them at higher risk of experiencing negative emotions if there is a mismatch between player skill and in-game challenge (see Gerling et al. [29] for anecdotal evidence of how games can trigger negative reflection on one's own body). In line with therapeutic practice reported in our work, games should therefore strive to consistently provide experiences of success, offering constructive rather than negative feedback. Hence, games need to move beyond existing approaches (e.g., [27, 77]), not just reducing, but completely avoiding instances of failure. One way of achieving this is refraining from providing negative feedback, for example neither communicating nor penalizing failure, and removing focus on quantitative performance indicators such as player scores. Another promising avenue is the employment of competence-enhancing design strategies that target game mechanics and task selection. For example, personalized games could initially present players with exercises they have successfully completed in the past to increase chances of success, and integrate adjustment mechanisms that allow for correction of game difficulty on the basis of subjective player experience and psychological player state (e.g., [26, 56]).

However, we also want to point out that **learning from therapeutic practice means applying care in judgement, and understanding the strengths and weaknesses of both games and physical therapy**: while our results indicate many instances in which game design can be improved through a deeper understanding of the therapeutic process, we also observed instances in which patient motivation was not optimally supported. We got to know physical therapy as a space devoid of meaningful provision of autonomy, an issue that is increasingly acknowledged within the rehabilitation research community (e.g., [63, 75]). Here, we are curious whether **game-based approaches could be leveraged to increase patient self-determination (Lesson 3)**: games have previously been leveraged to instill a sense of autonomy in players in constrained settings [66]. Additionally, they have potential to create space in which patients can be involved in meaningful goal-setting [44], and could support existing efforts in rehabilitation science to implement collaborative goal-setting [54].

Finally, our community needs to acknowledge that **human-led physical therapy may better support the patient experience in some situations, with games offering a means of supplementing them (Lesson 4)**. Here, we want to acknowledge the level of detail, care, and persistence with which therapists reported adjusting sessions in an effort to ensure patient well-being and safety to a degree that today's technology would struggle to achieve. Additionally, while we do of course acknowledge that games can provide meaningful social experiences (e.g., [34, 35]), the importance of relatedness in our work suggests that the human relationship between therapist and patient serves as a source of enjoyment and comfort that should be respected and supported by technical interventions. Therefore, we wonder whether a better perspective on games for

physical therapy would be that they serve as a supplementary technology (e.g., to make additional home exercises more engaging, and to better guide patients in these instances), rather than assuming they can replace in-person sessions.

#### 5.4 Self-Determination Theory as an Opportunity to Systematically Establish Evidence-Based Strategies to Support Patient Motivation in Game-based Physical Therapy and Beyond

Our results show that therapists have an intuitive understanding of the main concepts incorporated in Self-Determination Theory and their interplay, as for example evidenced by their efforts to compensate for a lack of patient autonomy through provision of substantial opportunities to experience competence, and a strong emphasis on relatedness, implicitly aligning with the key elements of BPNT. Here, our work contributes to the growing body of literature that sees merit in leveraging SDT as theoretical lens to understand physical therapy. However, in contrast to previous work that focused on explaining outcomes of physical therapy (e.g., [60]), we offer a new perspective on SDT as a tool to inform the design of physical therapy, with our analysis demonstrating how SDT can serve as a framework that supports structured reflection on how therapists organise sessions and approach patients. We particularly see potential in leveraging SDT to make previously implicit, intuition-based decisions explicit, thereby providing therapists with a tool to reflect on their choices and associated trade-offs. This is in line with findings from physical education research, where SDT is recommended as a framework that allows teachers to increase student engagement through teaching approaches that account for students' basic psychological needs, and through application of autonomy-supporting techniques [55]. In the context of games for physical therapy, the lens of SDT as a means of deconstructing traditional physical therapy offers an opportunity for researchers and designers to gain insights in and effectively model best practices that are applied by therapists. This would open up a design space for games that address physical therapy more holistically, moving beyond considerations regarding the functional elements of exercise.

Additionally, the application of SDT also allowed us to identify instances which offer opportunity to critically reflect on current practices in physical therapy, and identifying gaps that can potentially be addressed through technology. As previously outlined, our analysis showed that patients were given little space to experience autonomy within physical therapy, limiting their opportunity to become intrinsically motivated, which therapists rarely scaffolded toward. Here, relevant mini-theories of SDT can further contribute to a fine-grained understanding of patient motivation in physical therapy, potentially allowing therapists to develop approaches that specifically aim to support intrinsic motivation. Likewise, this opens up an opportunity for researchers and designers to craft technology-based interventions that specifically target inherent shortcomings of traditional therapy, e.g., by focusing on game-based approaches that prioritize autonomy support. However, we also want to acknowledge that this needs to be done under consideration of the general constraints of physical therapy and the limitations of games for physical therapy: while offering patients more autonomy may

**Table 1: Summary of the key lessons and recommendations from our analysis alongside the key observations that motivated them.**

<b>Key Lesson 1:</b> development of a more holistic perspective on adaptation in games for physical therapy	
<b>Observation</b> Therapists adjust sessions based on situational factors and individual traits of patients, e.g., patient’s emotions, patient’s personal preferences, and environmental factors.	<b>Recommendation</b> Sensors used to capture physiological measures are known to not work well with disabled bodies [42] and their use needs to be considered from an ethical perspective. We recommend the exploration and use of manual approaches to measure situational factors (e.g., [26]), and emphasise the need for more comprehensive initial set-up and calibration routines.
<b>Key Lesson 2:</b> viewing player performance through the lens of vulnerability	
<b>Observation</b> Physical therapy inherently focuses on tasks that are challenging for patients and therapists aim to ensure experiences of success through constructive rather than negative feedback.	<b>Recommendation</b> We recommend that game design completely avoid instances of failure, e.g., through avoiding provision of negative feedback and removing focus on quantitative performance indicators. We further suggest considering the use of competence-enhancing design strategies, e.g., initially presenting players with tasks they have successfully completed in the past, and adapting based on subjective player experience and psychological player state (e.g., [26]).
<b>Key Lesson 3:</b> games as an opportunity to increase patient self-determination	
<b>Observation</b> Our results suggest that physical therapy is often a space devoid of meaningful provision of autonomy.	<b>Recommendation</b> Games may offer a way to instil a sense of autonomy in this context [66], and involve patients in meaningful and collaborative goal-setting [44, 54].
<b>Key Lesson 4:</b> recognizing the limitations of game-based physical therapy and the unique value of human-led approaches	
<b>Observation</b> Therapists exert a level of detail, care, and persistence when adjusting sessions which today’s technology would struggle to achieve.	<b>Recommendation</b> We suggest viewing games as a supplementary technology, e.g., to support patients during home exercises, rather than trying to create them in a way that would replace human-led therapy.

support their motivation, other aspects such as health and safety also need to be considered, an aspect which is particularly relevant when working with children and adolescents. Likewise, there is evidence that games do not always support autonomy (e.g., depending on the (social) context [24]), which needs to be considered in their design and deployment.

## 6 LIMITATIONS AND FUTURE WORK

Our work needs to be interpreted in the light of a few limitations. Most importantly, due to the qualitative nature of our research approach, we only involved a small number of therapists who practice in Belgium in the interviews, and focused on those working in pediatric physical therapy. In the future, it may be valuable to involve additional therapists (e.g., those working with adults), and approach a bigger participant group, for example, by leveraging online surveys that examine therapeutic practice more widely. It

would also become possible to examine whether the relative uniformity of therapeutic approaches observed in our study is a result of the small sample size, or in fact due to broad use of comparable strategies.

We operationalise autonomy as choice in our interview questions and throughout our analysis, as this mirrors the approach to autonomy often taken in technology design (e.g., [82, 84]). However, in doing so, we limited our study of the concept and did not explore in-depth whether children acted out of their own volition. Further, our work—to date—only involves perspectives from therapists. While this was an explicit choice in the work presented here as we wanted to understand how they approach therapeutic practice, self-determination in physical therapy can and must also be viewed through the lens of the patient. In the future, we therefore aim to expand our work to incorporate perspectives of children and adolescents, and we are particularly curious to learn more about their experience of autonomy (support) in the context of physical therapy.

Building on this more comprehensive perspective, we plan to derive a framework for the integration of SDT in games for physical therapy, which we plan to further refine through analysis of existing games in this space. Finally, our work has been of theoretical nature, and we are excited to further examine implications of our results presented here through implementation in and evaluation of game prototypes to support physical therapy.

## 7 CONCLUSION

Many attempts to leverage games to support physical therapy have been made in the past, assuming an inherent ‘motivational pull’ superior to that of human-led physical therapy. However, relatively little attention has been paid to what HCI games research can learn from how therapists work with patients in an effort to inform game design through therapeutic practice. Leveraging Self-Determination Theory and its mini-theories Basic Psychological Needs Theory and Organismic Integration Theory as a theoretical lens, we close this gap and show that patient motivation plays an important role—particularly in physical therapy for children and adolescents—with therapists applying various strategies to carefully adjust physical therapy sessions and engage patients, going beyond what is currently offered by games. Hence, our work contributes implications for the design of games for physical therapy; however, it also needs to be understood as a reminder for our community to ensure that we carefully study roles and context of activities that we seek to replace or augment through interactive technology. Here, our work presents a first step toward understanding therapeutic practice more comprehensively, and offers insights that can serve as a stepping stone toward theory-driven design and development of adaptive games for physical therapy that are rooted in an understanding and appreciation of game design and therapeutic practice alike.

## ACKNOWLEDGMENTS

This research has been funded as part of a KU Leuven internal funds C2 project, a Research Foundation – Flanders PhD fellowship fundamental research project (number 11E9122N), and the Excellence Strategy of the German Federal and State Governments.

The authors thank all participants for their valuable insights and contribution to this research project. Further, they thank Fien Bostijn for her help in transcribing the interviews.

## REFERENCES

- [1] Nicole Adams, Todd D. Little, and Richard M. Ryan. 2017. *Self-Determination Theory*. Springer Netherlands, Dordrecht, 47–54. [https://doi.org/10.1007/978-94-024-1042-6\\_4](https://doi.org/10.1007/978-94-024-1042-6_4)
- [2] Gazihan Alankus, Amanda Lazar, Matt May, and Caitlin Kelleher. 2010. Towards Customizable Games for Stroke Rehabilitation. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Atlanta, Georgia, USA) (CHI '10). Association for Computing Machinery, New York, NY, USA, 2113–2122. <https://doi.org/10.1145/1753326.1753649>
- [3] Thematic Analysis. [n.d.]. Thematic Analysis. <http://thematicanalysis.net>. Accessed: 2022-09-09.
- [4] Dennis Ang and Alex Mitchell. 2017. Comparing Effects of Dynamic Difficulty Adjustment Systems on Video Game Experience. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play* (Amsterdam, The Netherlands) (CHI PLAY '17). Association for Computing Machinery, New York, NY, USA, 317–327. <https://doi.org/10.1145/3116595.3116623>
- [5] Madeline Balaam, Stefan Rennick Egglestone, Geraldine Fitzpatrick, Tom Rodden, Ann-Marie Hughes, Anna Wilkinson, Thomas Nind, Lesley Axelrod, Eric Harris, Ian Ricketts, Susan Mawson, and Jane Burridge. 2011. Motivating Mobility: Designing for Lived Motivation in Stroke Rehabilitation. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Vancouver, BC, Canada) (CHI '11). Association for Computing Machinery, New York, NY, USA, 3073–3082. <https://doi.org/10.1145/1978942.1979397>
- [6] N. Ben Itzhak, I. Franki, B. Jansen, K. Kostkova, J. Wagemans, and E. Ortibus. 2022. An Individualized and Adaptive Game-Based Therapy for Cerebral Visual Impairment: Design, Development, and Evaluation. *International Journal of Child-Computer Interaction* 31 (2022), 100437. <https://doi.org/10.1016/j.ijcci.2021.100437>
- [7] Marte Bentzen and Linn Kristin Malmquist. 2022. Differences in Participation Across Physical Activity Contexts Between Adolescents with and without Disability over Three Years: A Self-Determination Theory Perspective. *Disability and Rehabilitation* 44, 9 (2022), 1660–1668. <https://doi.org/10.1080/09638288.2021.1894489>
- [8] Sam Blanchard and Phil Glasgow. 2014. A Theoretical Model to Describe Progressions and Regressions for Exercise Rehabilitation. *Physical Therapy in Sport* 15, 3 (2014), 131–135. <https://doi.org/10.1016/j.ptsp.2014.05.001>
- [9] Bruno Bonnechère, Bart Jansen, Lubos Omelina, Lucie Da Silva, Jennifer Mougéat, Valerie Heymans, Annick Vandeuuren, Marcel Rooze, and Serge Van Sint Jan. 2013. *Use of Serious gaming to increase motivation of cerebral palsy children during rehabilitation*.
- [10] Bruno Bonnechère, Bart Jansen, Lubos Omelina, Serge Van Sint Jan, et al. 2016. The use of commercial video games in rehabilitation: a systematic review. *International journal of rehabilitation research* 39, 4 (2016), 277–290.
- [11] Virginia Braum and Victoria Clarke. 2021. *Thematic Analysis: A Practical Guide*. SAGE Publications Ltd.
- [12] Stephanie P Brooks and Tania Bubela. 2020. Application of protection motivation theory to clinical trial enrolment for pediatric chronic conditions. *BMC pediatrics* 20, 1 (2020), 1–14.
- [13] Chantal Camden, Gabrielle Pratte, Florence Fallon, Mélanie Couture, Jade Berbari, and Michel Tousignant. 2020. Diversity of practices in telerehabilitation for children with disabilities and effective intervention characteristics: results from a systematic review. *Disability and Rehabilitation* 42, 24 (2020), 3424–3436. <https://doi.org/10.1080/09638288.2019.1595750> PMID: 30978110
- [14] Sung Hyeon Cheon, Johnmarshall Reeve, Jaewon Lee, and Youngsun Lee. 2015. Giving and receiving autonomy support in a high-stakes sport context: A field-based experiment during the 2012 London Paralympic Games. *Psychology of Sport and Exercise* 19 (2015), 59–69. <https://doi.org/10.1016/j.psychsport.2015.02.007>
- [15] Sung Hyeon Cheon, Johnmarshall Reeve, and Ik Soo Moon. 2012. Experimentally Based, Longitudinally Designed, Teacher-Focused Intervention to Help Physical Education Teachers Be More Autonomy Supportive Toward Their Students. *Journal of Sport and Exercise Psychology* 34, 3 (2012), 365–396. <https://doi.org/10.1123/jsep.34.3.365>
- [16] Gabriele Cimolino, Sussan Askari, and T.C. Nicholas Graham. 2021. The Role of Partial Automation in Increasing the Accessibility of Digital Games. *Proc. ACM Hum.-Comput. Interact.* 5, CHI PLAY, Article 266 (oct 2021), 30 pages. <https://doi.org/10.1145/3474693>
- [17] Paul Comfort and Martyn Matthews. 2010. *An Introduction to Periodisation*. John Wiley & Sons, Ltd, Chapter 9, 143–161. <https://doi.org/10.1002/9781118685150.ch9>
- [18] Robin De Croon, Jonas Geuens, Katrien Verbert, and Vero Vanden Abeele. 2021. A systematic review of the effect of gamification on adherence across disciplines. In *International Conference on Human-Computer Interaction*. Springer, 168–184.
- [19] Mihaly Csikszentmihalyi and Mihaly Csikszentmihalyi. 1990. *Flow: The psychology of optimal experience*. Vol. 1990. Harper & Row New York.
- [20] Robin De Croon, Davina Wildemeersch, Joris Wille, Katrien Verbert, and Vero Vanden Abeele. 2018. Gamification and Serious Games in a Healthcare Informatics Context. In *2018 IEEE International Conference on Healthcare Informatics (ICHI)*. 53–63. <https://doi.org/10.1109/ICHI.2018.00014>
- [21] Edward L. Deci and Richard M. Ryan. 1985. *Intrinsic Motivation and Self-Determination in Human Behavior*. NY: Plenum.
- [22] Edward L. Deci and Richard M. Ryan. 2000. The “What” and “Why” of Goal Pursuits: Human Needs and the Self-Determination of Behavior. *Psychological Inquiry* 11, 4 (2000), 227–268. [https://doi.org/10.1207/S15327965PLI1104\\_01](https://doi.org/10.1207/S15327965PLI1104_01)
- [23] DeepL. [n.d.]. DeepL Translator. <https://www.deepl.com/translator>. Accessed: 2022-09-09.
- [24] Sebastian Deterding. 2016. Contextual Autonomy Support in Video Game Play: A Grounded Theory. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (San Jose, California, USA) (CHI '16). Association for Computing Machinery, New York, NY, USA, 3931–3943. <https://doi.org/10.1145/2858036.2858395>
- [25] Eletha Flores, Gabriel Tobon, Ettore Cavallaro, Francesca I Cavallaro, Joel C Perry, and Thierry Keller. 2008. Improving patient motivation in game development for motor deficit rehabilitation. In *Proceedings of the 2008 international conference on advances in computer entertainment technology*. 381–384.
- [26] Julian Frommel, Claudia Schrader, and Michael Weber. 2018. Towards emotion-based adaptive games: Emotion recognition via input and performance features. In *Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in*

- Play. 173–185.
- [27] Kathrin Gerling, Kieran Hicks, Olivier Szymanczyk, and Conor Linehan. 2019. Designing Interactive Manual Wheelchair Skills Training for Children. In *Proceedings of the 2019 on Designing Interactive Systems Conference* (San Diego, CA, USA) (DIS '19). Association for Computing Machinery, New York, NY, USA, 725–736. <https://doi.org/10.1145/3322276.3322281>
- [28] Kathrin Gerling, Ian Livingstone, Lennart Nacke, and Regan Mandryk. 2012. Full-Body Motion-Based Game Interaction for Older Adults. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Austin, Texas, USA) (CHI '12). Association for Computing Machinery, New York, NY, USA, 1873–1882. <https://doi.org/10.1145/2207676.2208324>
- [29] Kathrin M. Gerling, Regan L. Mandryk, and Conor Linehan. 2015. Long-Term Use of Motion-Based Video Games in Care Home Settings. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (Seoul, Republic of Korea) (CHI '15). Association for Computing Machinery, New York, NY, USA, 1573–1582. <https://doi.org/10.1145/2702123.2702125>
- [30] Luc Geurts, Vero Vanden Abeele, Jelle Husson, Frederik Windey, Maarten Van Overveldt, Jan-Henk Annema, and Stef Desmet. 2010. Digital games for physical therapy: fulfilling the need for calibration and adaptation. In *Proceedings of the fifth international conference on Tangible, embedded, and embodied interaction*. 117–124.
- [31] Birgitta Grahm, Carl Ekdahl, and Lars Borgquist. 2000. Motivation as a predictor of changes in quality of life and working ability in multidisciplinary rehabilitation. *Disability and Rehabilitation* 22, 15 (2000), 639–654.
- [32] Emma J. Grindley and Samuel J. Zizzi. 2005. Using a Multidimensional Approach to Predict Motivation and Adherence to Rehabilitation in Older Adults. *Topics in Geriatric Rehabilitation* 21, 3 (Jul 2005), 182–193. <https://doi.org/10.1097/00013614-200507000-00004>
- [33] Emma J Grindley, Samuel J Zizzi, and Alan M Nasypany. 2008. Use of Protection Motivation Theory, Affect, and Barriers to Understand and Predict Adherence to Outpatient Rehabilitation. *Physical Therapy* 88, 12 (12 2008), 1529–1540. <https://doi.org/10.2522/ptj.20070076> arXiv:<https://academic.oup.com/ptj/article-pdf/88/12/1529/9984598/ptj1529.pdf>
- [34] John Harris and Mark Hancock. 2019. To Asymmetry and Beyond! Improving Social Connectedness by Increasing Designed Interdependence in Cooperative Play. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) (CHI '19). Association for Computing Machinery, New York, NY, USA, 1–12. <https://doi.org/10.1145/3290605.3300239>
- [35] Hamilton A. Hernandez, Mallory Ketcheson, Adrian Schneider, Zi Ye, Darcy Fehlings, Lauren Switzer, Virginia Wright, Shelly K. Bursick, Chad Richards, and T.C. Nicholas Graham. 2014. Design and Evaluation of a Networked Game to Support Social Connection of Youth with Cerebral Palsy. In *Proceedings of the 16th International ACM SIGACCESS Conference on Computers & Accessibility* (Rochester, New York, USA) (ASSETS '14). Association for Computing Machinery, New York, NY, USA, 161–168. <https://doi.org/10.1145/2661334.2661370>
- [36] Hamilton A. Hernandez, Zi Ye, T.C. Nicholas Graham, Darcy Fehlings, and Lauren Switzer. 2013. Designing Action-Based Exergames for Children with Cerebral Palsy. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Paris, France) (CHI '13). Association for Computing Machinery, New York, NY, USA, 1261–1270. <https://doi.org/10.1145/2470654.2466164>
- [37] Christopher J. Holt, Carly D. McKay, Linda K. Truong, Christina Y. Le, Douglas P. Gross, and Jackie L. Whittaker. 2020. Sticking to It: A Scoping Review of Adherence to Exercise Therapy Interventions in Children and Adolescents With Musculoskeletal Conditions. *Journal of Orthopaedic & Sports Physical Therapy* 50, 9 (2020), 503–515. <https://doi.org/10.2519/jospt.2020.9715>
- [38] Kay Howell. 2005. Games for health conference 2004: issues, trends, and needs unique to games for health. *Cyberpsychology & Behavior* 8, 2 (2005), 103–109.
- [39] Susan Hwang, Adrian L. Jessup Schneider, Daniel Clarke, Alexander Macintosh, Lauren Switzer, Darcy Fehlings, and T.C. Nicholas Graham. 2017. How Game Balancing Affects Play: Player Adaptation in an Exergame for Children with Cerebral Palsy. In *Proceedings of the 2017 Conference on Designing Interactive Systems* (Edinburgh, United Kingdom) (DIS '17). Association for Computing Machinery, New York, NY, USA, 699–710. <https://doi.org/10.1145/3064663.3064664>
- [40] Daniel Johnson, M John Gardner, and Ryan Perry. 2018. Validation of two game experience scales: the player experience of need satisfaction (PENS) and game experience questionnaire (GEQ). *International Journal of Human-Computer Studies* 118 (2018), 38–46.
- [41] Hee-Tae Jung, Taiwoo Park, Narges MAhyar, Sungji Park, Taekyeong Ryu, Yangsoo Kim, and Sunghoon Ivan Lee. 2020. Rehabilitation Games in Real-World Clinical Settings: Practices, Challenges, and Opportunities. *ACM Trans. Comput.-Hum. Interact.* 27, 6, Article 41 (nov 2020), 43 pages. <https://doi.org/10.1145/3418197>
- [42] Shaun K. Kane, Anhong Guo, and Meredith Ringel Morris. 2020. Sense and Accessibility: Understanding People with Physical Disabilities' Experiences with Sensing Systems. In *The 22nd International ACM SIGACCESS Conference on Computers and Accessibility* (Virtual Event, Greece) (ASSETS '20). Association for Computing Machinery, New York, NY, USA, Article 42, 14 pages. <https://doi.org/10.1145/3373625.3416990>
- [43] Pamela M Kato. 2010. Video games in health care: Closing the gap. *Review of general psychology* 14, 2 (2010), 113–121.
- [44] Fares Kayali, Naemi Luckner, Peter Purgathofer, Katta Spiel, and Geraldine Fitzpatrick. 2018. Design Considerations towards Long-Term Engagement in Games for Health. In *Proceedings of the 13th International Conference on the Foundations of Digital Games* (Malmö, Sweden) (FDG '18). Association for Computing Machinery, New York, NY, USA, Article 35, 8 pages. <https://doi.org/10.1145/3235765.3235789>
- [45] Marc-André K Lafrenière, Jérémie Verner-Filion, and Robert J Vallerand. 2012. Development and validation of the Gaming Motivation Scale (GAMS). *Personality and individual differences* 53, 7 (2012), 827–831.
- [46] Li Li and Dennis Moore. 1998. Acceptance of disability and its correlates. *The Journal of social psychology* 138, 1 (1998), 13–25.
- [47] Keith Lohse, Navid Shirzad, Alida Verster, Nicola Hodges, and HF Machiel Van der Loos. 2013. Video games and rehabilitation: using design principles to enhance engagement in physical therapy. *Journal of Neurologic Physical Therapy* 37, 4 (2013), 166–175.
- [48] Eugène Loos and Annemiek Zonneveld. 2016. Silver Gaming: Serious Fun for Seniors?. In *Human Aspects of IT for the Aged Population. Healthy and Active Aging*, Jia Zhou and Gavriel Salvendy (Eds.). Springer International Publishing, Cham, 330–341.
- [49] Niall Maclean, Pandora Pound, C Wolfe, A Rudd, et al. 2000. A critical review of the concept of patient motivation in the literature on physical rehabilitation. *Soc Sci Med* 50, 4 (2000), 495–506.
- [50] Annette Majnemer, Keiko Shikako-Thomas, Lucy Lach, Michael Shevell, Mary Law, and Norbert Schmitz. 2013. Mastery Motivation in Adolescents with Cerebral Palsy. *Research in Developmental Disabilities* 34, 10 (2013), 3384–3392. <https://doi.org/10.1016/j.ridd.2013.07.002>
- [51] Mitchell McEwan, Cody Phillips, Peta Wyeth, and Daniel Johnson. 2020. Puppy Island: Theory-Driven Design of a Serious Game for Young Children with Cystic Fibrosis. In *Proceedings of the Interaction Design and Children Conference* (London, United Kingdom) (IDC '20). Association for Computing Machinery, New York, NY, USA, 532–540. <https://doi.org/10.1145/3392063.3394435>
- [52] Pieter Meyns, Tine Roman de Mettelinge, Judith van der Spank, Marieke Coussens, and Hilde Van Waelvelde. 2018. Motivation in Pediatric Motor Rehabilitation: A Systematic Search of the Literature Using the Self-Determination Theory as a Conceptual Framework. *Developmental Neurorehabilitation* 21, 6 (2018), 371–390. <https://doi.org/10.1080/17518423.2017.1295286>
- [53] Jeanne Nakamura and Mihaly Csikszentmihalyi. 2014. *The Concept of Flow*. Springer Netherlands, Dordrecht, 239–263. [https://doi.org/10.1007/978-94-017-9088-8\\_16](https://doi.org/10.1007/978-94-017-9088-8_16)
- [54] Linda Nguyen, Andrea Cross, Peter Rosenbaum, and Jan Willem Gorter. 2021. Use of the International Classification of Functioning, Disability and Health to support goal-setting practices in pediatric rehabilitation: a rapid review of the literature. *Disability and Rehabilitation* 43, 6 (2021), 884–894.
- [55] Nikos Ntoumanis and Martyn Standage. 2009. Motivation in physical education classes: A self-determination theory perspective. *Theory and research in education* 7, 2 (2009), 194–202.
- [56] Manuel Pezzerà and N. Alberto Borghese. 2020. Dynamic difficulty adjustment in exergames for rehabilitation: a mixed approach. In *2020 IEEE 8th International Conference on Serious Games and Applications for Health (SeGAH)*. 1–7. <https://doi.org/10.1109/SeGAH49190.2020.9201871>
- [57] Johannes Pfau, Jan David Smeddinck, and Rainer Malaka. 2020. Enemy within: Long-term motivation effects of deep player behavior models for dynamic difficulty adjustment. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. 1–10.
- [58] Michele Pirovano, Renato Mainetti, Gabriel Baud-Bovy, Pier Luca Lanzi, and Nunzio Alberto Borghese. 2012. Self-adaptive games for rehabilitation at home. In *2012 IEEE Conference on Computational Intelligence and Games (CIG)*. IEEE, 179–186.
- [59] Leslie Podlog, John Heil, and Stefanie Schulte. 2014. Psychosocial factors in sports injury rehabilitation and return to play. *Physical Medicine and Rehabilitation Clinics* 25, 4 (2014), 915–930.
- [60] Anne A. Poulsen, Sylvia Rodger, and Jenny M. Ziviani. 2006. Understanding Children's Motivation from a Self-Determination Theoretical Perspective: Implications for Practice. *Australian Occupational Therapy Journal* 53, 2 (2006), 78–86. <https://doi.org/10.1111/j.1440-1630.2006.00569.x>
- [61] Brian A. Primack, Mary V. Carroll, Megan McNamara, Mary Lou Klem, Brandy King, Michael Rich, Chun W. Chan, and Smita Nayak. 2012. Role of Video Games in Improving Health-Related Outcomes: A Systematic Review. *American Journal of Preventive Medicine* 42, 6 (2012), 630–638.
- [62] B Rabin, G Burdea, J Hundal, D Roll, and F Damiani. 2011. Integrative motor, emotive and cognitive therapy for elderly patients chronic post-stroke A feasibility study of the BrightArm™ rehabilitation system. In *2011 International Conference on Virtual Rehabilitation*. IEEE, 1–8.
- [63] Rachel Jane Rahman, Joanne Hudson, Cecile Thøgersen-Ntoumani, and Jonathan H. Doust. 2015. Motivational processes and well-being in cardiac rehabilitation: a self-determination theory perspective. *Psychology, Health & Medicine* 20, 5 (2015), 518–529. <https://doi.org/10.1080/13548506.2015.1017509>

- arXiv:<https://doi.org/10.1080/13548506.2015.1017509> PMID: 25753948.
- [64] Johnmarshall Reeve. 2006. Teachers as Facilitators: What Autonomy-Supportive Teachers Do and Why Their Students Benefit. *The Elementary School Journal* 106, 3 (2006), 225–236. <https://doi.org/10.1086/501484> arXiv:<https://doi.org/10.1086/501484>
- [65] Ryan E Rhodes and Bonnie Fiala. 2009. Building motivation and sustainability into the prescription and recommendations for physical activity and exercise therapy: the evidence. *Physiotherapy theory and practice* 25, 5-6 (2009), 424–441.
- [66] Chad Richards and T.C. Nicholas Graham. 2016. Developing Compelling Repetitive-Motion Exergames by Balancing Player Agency with the Constraints of Exercise. In *Proceedings of the 2016 ACM Conference on Designing Interactive Systems* (Brisbane, QLD, Australia) (DIS '16). Association for Computing Machinery, New York, NY, USA, 911–923. <https://doi.org/10.1145/2901790.2901824>
- [67] Ronald W Rogers and Steven Prentice-Dunn. 1997. Protection motivation theory. (1997).
- [68] Shari A Rone-Adams, Debra F Stern, and Vicki Walker. 2004. Stress and compliance with a home exercise program among caregivers of children with disabilities. *Pediatric physical therapy* 16, 3 (2004), 140–148.
- [69] Peter Rosenbaum, Nigel Paneth, Alan Leviton, Murray Goldstein, Martin Bax, Diane Damiano, Bernard Dan, Bo Jacobsson, et al. 2007. A report: The Definition and Classification of Cerebral Palsy April 2006. *Dev Med Child Neurol Suppl.* 109, suppl 109 (2007), 8–14.
- [70] Richard M. Ryan and Edward L. Deci. 2000. The Darker and Brighter Sides of Human Existence: Basic Psychological Needs as a Unifying Concept. *Psychological Inquiry* 11, 4 (2000), 319–338. [https://doi.org/10.1207/S15327965PLI1104\\_03](https://doi.org/10.1207/S15327965PLI1104_03)
- [71] Richard M. Ryan and Edward L. Deci. 2000. Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemporary Educational Psychology* 25, 1 (2000), 54–67. <https://doi.org/10.1006/ceps.1999.1020>
- [72] Richard M. Ryan and Edward L. Deci. 2000. Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being. *American Psychologist* 55, 1 (2000), 68–78. <https://doi.org/10.1037/0003-066X.55.1.68>
- [73] Richard M Ryan and Edward L Deci. 2017. *Self-determination theory: Basic psychological needs in motivation, development, and wellness*.
- [74] Richard M. Ryan, C. Scott Rigby, and Andrew Przybylski. 2006. The Motivational Pull of Video Games: A Self-Determination Theory Approach. *Motivation and Emotion* 30, 4 (2006), 344–360. <https://doi.org/10.1007/s11031-006-9051-8> The IMI items are available online under: <http://selfdeterminationtheory.org/intrinsic-motivation-inventory/>. Accessed: 09.09.2022.
- [75] Martin Saebu, Marit Sørensen, and Hallgeir Halvari. 2013. Motivation for physical activity in young adults with physical disabilities during a rehabilitation stay: a longitudinal test of self-determination theory. *Journal of Applied Social Psychology* 43, 3 (2013), 612–625. <https://doi.org/10.1111/j.1559-1816.2013.01042.x>
- [76] Joseph P Salisbury, Ted M Aronson, and Tony J Simon. 2020. At-home self-administration of an immersive virtual reality therapeutic game for post-stroke upper limb rehabilitation. In *Extended abstracts of the 2020 annual symposium on computer-human interaction in play*. 114–121.
- [77] Adrian L. Jessup Schneider, Kathy Keiver, Alison Pritchard Orr, James N. Reynolds, Neven Golubovich, and T.C. Nicholas Graham. 2020. Toward the Design of Enjoyable Games for Children with Fetal Alcohol Spectrum Disorder. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) (CHI '20). Association for Computing Machinery, New York, NY, USA, 1–13. <https://doi.org/10.1145/3313831.3376480>
- [78] Emmy M Sluijs, Gerjo J Kok, and Jouke van der Zee. 1993. Correlates of Exercise Compliance in Physical Therapy. *Physical Therapy* 73, 11 (11 1993), 771–782. <https://doi.org/10.1093/ptj/73.11.771> arXiv:<https://academic.oup.com/ptj/article-pdf/73/11/771/10760180/ptj0771.pdf>
- [79] Jan David Smeddinck, Marc Herrlich, and Rainer Malaka. 2015. Exergames for Physiotherapy and Rehabilitation: A Medium-Term Situated Study of Motivational Aspects and Impact on Functional Reach. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (Seoul, Republic of Korea) (CHI '15). Association for Computing Machinery, New York, NY, USA, 4143–4146. <https://doi.org/10.1145/2702123.2702598>
- [80] Alexander Streicher and Jan D Smeddinck. 2016. Personalized and adaptive serious games. In *Entertainment computing and serious games*. Springer, 332–377.
- [81] Pedro J Teixeira, Eliana V Carraça, David Markland, Marlene N Silva, and Richard M Ryan. 2012. Exercise, physical activity, and self-determination theory: a systematic review. *International journal of behavioral nutrition and physical activity* 9, 1 (2012), 1–30.
- [82] April Tyack and Elisa D. Mekler. 2020. Self-Determination Theory in HCI Games Research: Current Uses and Open Questions. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) (CHI '20). Association for Computing Machinery, New York, NY, USA, 1–22. <https://doi.org/10.1145/3313831.3376723>
- [83] Stephen Uzor and Lynne Baillie. 2019. Recov-R: evaluation of a home-based tailored exergame system to reduce fall risk in seniors. *ACM Transactions on Computer-Human Interaction (TOCHI)* 26, 4 (2019), 1–38.
- [84] Gabriela Villalobos-Zúñiga, Iyubanit Rodríguez, Anton Fedosov, and Mauro Cherubini. 2021. Informed Choices, Progress Monitoring and Comparison with Peers: Features to Support the Autonomy, Competence and Relatedness Needs, as Suggested by the Self-Determination Theory. In *Proceedings of the 23rd International Conference on Mobile Human-Computer Interaction* (Toulouse & Virtual, France) (*MobileHCI '21*). Association for Computing Machinery, New York, NY, USA, Article 13, 14 pages. <https://doi.org/10.1145/3447526.3472039>
- [85] Jenny Ziviani. 2015. Occupational Performance: A Case for Self-Determination. *Australian Occupational Therapy Journal* 62, 6 (2015), 393–400. <https://doi.org/10.1111/1440-1630.12250>