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Therapy gamification to improve children compliance. A systematic literature review.

Giulia Teverini[1,2], Annamaria Recupero[2], Patrizia Marti [2]

[1] Università degli Studi della Campania "Luigi Vanvitelli"
[2] Università degli Studi di Siena

Abstract. In the healthcare domain there is a growing body of literature addressing the use of games and gamification strategies which go beyond entertainment to positively affect the therapy outcomes and the health status of the patients. This represents an emerging field of experimentation that requires a holistic perspective to consider both the medical requirements and the patients' characteristics and needs. When approaching this topic, a common framework to guide the game design process is missing. To fill this gap, this paper reports a systematic literature review about the use of games and gamification strategies to stimulate children's compliance in different therapeutic contexts. The objective is to analyse the state of the art by identifying both opportunities and constraints, and derive a common framework to guide the future design of games. The results show that games and gamification strategies are used in both pharmacological therapy and non-pharmacological therapy, to directly increase the compliance (for practising rehabilitation exercises, for adopting healthy behaviours) or to indirectly affect the compliance for example by making the therapy enjoyable. By categorising the existing literature, it emerged a main conceptual distinction between "therapeutic games" and "games for therapy", which have peculiar characteristics and implications for their design and evaluation.

Keywords: literature review, therapy, healthcare, children, compliance, game, gamification, game design, therapeutic games, games for therapy.

1 Introduction

The success of healthcare interventions strongly depends on the willingness and motivation of the patients to adequately follow the prescribed treatment and to adopt healthy habits which improve the health status (e.g., healthy nutrition, physical exercise). The compliance is the extent to which a person's behaviour - taking medication, practicing rehabilitation exercises, following a diet, and/or executing lifestyle changes - corresponds with agreed recommendations from the healthcare provider. The compliance with the treatment is a critical factor especially when the

[1] Corresponding author: Giulia Teverini, giulia.teverini@unicampania.it

patients are children, and in case of painful or demanding long-term treatment regimes. This applies to temporary and chronic conditions, to pharmacological and non-pharmacological therapies.

The scientific debate about this topic has a long tradition and the literature provides evidence about the different factors affecting the compliance, as well as suggestions for the clinical practice (e.g. [34, 10, 39, 13]).

One of the strategies to improve children's compliance with the treatment is based on the use of games and gamification mechanisms. The term gamification has been coined as an umbrella term to indicate the practice of introducing game elements to motivate and engage people in non-game contexts [9]. This could happen by developing a videogame or a boardgame, or simply by introducing a game-like reward system, depending on the therapy contexts and objectives.

Recently there was a growing body of research in this domain, but a clear picture is missing. The scientific literature about the use of gamification in healthcare contexts is extremely wide, and fragmented, as it includes scientific contributions ranging from single case studies to literature reviews that try to depict the state of the art. To navigate this universe, the literature reviews are useful to understand what is missing and to position different approaches and methods in a systematic way. Indeed, existing literature reviews mainly focus on the use of gamification in specific purpose-oriented health interventions, while there is the need to understand how designers can introduce "game-like" dynamics into routine activities to engage patients according to the therapy context. For example, Suleiman-Martos et al. [33] carried out a systematic review to explore the effect of gamification to foster food related attitude and behaviours in children and adolescents. The literature review by Peñuelas-Calvo et al. [28] investigated the effectiveness of video games for the treatment of attention-deficit/hyperactivity disorder in children, while Xie [37] conducted a scoping review to study the impact of gamification approaches in mental healthcare in children and adolescents. Finally, Fijačko et al. [11] analysed the effects of gamification features in mobile apps to support the oral self-care and oral hygiene in children.

While these reviews provide relevant evidence, none have revealed a common ground which can inform designers to develop gamification strategies for therapy purposes. On the other hand, the existing taxonomies of games for entertainment do not provide specific guidelines to design gamification strategies for healthcare purposes.

To fill this gap, the systematic literature review discussed in this paper aims to advance the knowledge by shedding light on the opportunities and contrasts from a game design perspective, considering diverse therapeutic contexts, to provide a common framework for the future design practices.

2 Objective and methodology

The aim of this study is to map the state of art of gamification in therapeutic contexts, to describe the characteristics of the games and their impact on the compliance from a design-oriented perspective. The systematic literature review is an essential inquiry methodology to summarise, analyse, and synthesise the existing knowledge, serving as background for the future empirical research [36].

Considering the gaps in the current knowledge, the Research Questions (RQs) which guided the literature review are exploratory in nature rather than hypotheses to confirm [36].

- RQ1 Which therapies make use of gamification mechanisms?
- RQ2: What are the expected impacts in terms of compliance from the implementation of gamification mechanisms in the therapy?
- RQ3: According to the specific treatment protocol, what are the gamification mechanics implemented in the therapy to facilitate the compliance?
- RQ4: What roles do the end user and other stakeholders (e.g. health experts, families) play in the design process?

Notably, the RQ2 intentionally mentions the "expected" impacts to not exclude the studies in which the actual impact on the compliance is not (yet) assessed and reported. Moreover, the RQ4 was defined to focus the analysis on the design process, while the other RQs are focused on the design output. Indeed, we acknowledge that the design process and the people involved in the process affect the characteristics and quality of the final product.

The methodology of the systematic literature review included three phases as described below.

1) Research design: in this phase, the research team formulated the RQs and shared a common definition of the concepts (e.g., therapy, gamification, design process), identified relevant databases and keywords to be used, and defined the inclusion and exclusion criteria.
2) Data collection: in this phase, the records were identified, included or excluded based on the selection criteria. The first screening was performed based on the metadata (e.g., publication type). The second screening was performed based on title and abstract reading. The third screening was performed based on full text reading.
3) Data analysis: in this phase, the selected records were analysed to extract the relevant information, and they were clustered to answer the RQs.

The database search was carried out in September 2023. No restrictions were set regarding the year of publication. We identified five databases to consult, which all together allowed us to collect records in the technology, design and health domains: ACM Digital Library, Scopus, Web of Science, PubMed and IEEE Xplore.

The database search was carried out using the search equation "children AND (therapy OR treatment) AND (game OR gamification) AND device", combining the Boolean "AND" with "OR" to broaden the research field, since some terms are commonly used as synonyms. The search equation was adjusted to adhere to the specific syntax rules of each search engine database. Notably, the use of the keyword "device" is relevant for the design-oriented approach of this study, to collect records about medical devices and/or devices used for playing the game.

The inclusion and exclusion criteria are listed in Table 1.

Table 1. Inclusion and exclusion criteria used for the screening process.

Criterion	Inclusion	Exclusion
Language	English	Other languages (e.g., Spanish, Chinese, Russian, Italian etc.)
Full-text availability	Full text available	Full text not available
Publication type	Journal and Conference proceedings	Theses, Book, Poster
Article type	Research article	Literature review, Position paper, Workshop proposal, Extended Abstract, Grey literature
Target population	Children	Infants, Young adults, Adults, Older adults
Details included in the record	Enough details about the therapy, gamification elements, design process	Lack of details about the therapy, gamification elements, design process

The criterion of the article type served to collect records as research articles to directly analyse the studies, without considering short contributions (e.g., extended abstract), theoretical perspectives (e.g., position papers), nor elaboration of the scientific literature (e.g., literature review).

In addition to the language, publication type, article type, and target population, we included an additional criterion: to select the records exploring the interplay between therapy for children and gamification elements, and detailing the design process. To apply this criterion the research team decided to include records which can be framed as follows:

- the healthcare therapy is the research context;
- the children (2-13 years old) are the main recipients of the therapy;
- the study develops a game to improve children compliance with treatment or, at least, introduces one gamification mechanic according to the taxonomy proposed by Hervás et al. [15];
- a clear description of the design process is provided to show how the researcher/s come up with the concept/s of a gamified therapy and how the stakeholders are involved in the process.

Based on this common framework, the data collection was performed as described in the following paragraph.

2.1 Data collection

Once the research design methodology was defined, a member of the team performed the data collection through database search and record screening. As a check of the database searching, another team member repeated the searching process using the same databases and keywords to ensure consistency in the identified records.
Figure 1 shows the process and the numbers of records identified, included and excluded during the screening.

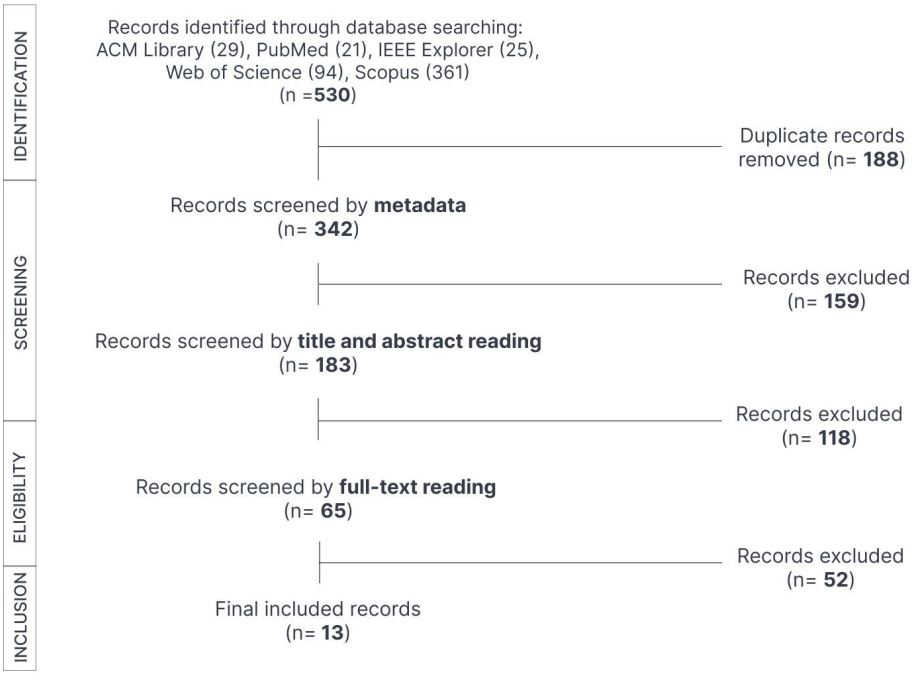

Fig. 1. Flow diagram of the data collection process.

The database search retrieved a total of 530 records: 29 records are from ACM Digital Library, 21 records are from PubMed, 25 records are from IEEE Xplore, 94 records are from Web of Science, 361 records are from Scopus.

After removing the duplicates through the inspection of the digital object identifiers (DOIs), 342 records have been screened based on the metadata to exclude the records which did not meet the criteria of language (n=18), publication type (n=65) and full-text availability (n=75).

The next step was to screen the remaining 183 records by reading their title and abstract. 118 records were excluded because they did not meet the inclusion criteria. The final step was to screen the 65 records by full-text reading to determine whether they report enough information to answer the RQs. At the end, 13 records were identified as eligible and analysed. Table 2 lists the eligible records with their ID numbers, author/s, and title.

Table 2. List of eligible records.

ID	Year	Authors	Title
01	2023	Damasceno, E. F., da Silva, A. P., Barbosa, J. D.	A serious game-based platform for measuring treatment adherence
02	2021	Amato, F., Di Gregorio, M., Monaco, C., Sebillo, M., Tortora, G., Vitiello, G.	Socially assistive robotics combined with artificial intelligence for ADHD.
03	2022	Subramaniam, A., Hensley, E., Stojancic, R., Vaughn, J., Shah, N.	Careful considerations for mHealth app development: lessons learned from QuestExplore.
04	2023	Valencia-Jiménez, N. J., Ramírez-Duque, A. A., Rodríguez-Timaná, L. C., Castillo-García, J. F., Silveira, M. L., Da Luz, S., Frizera-Neto, A.	Effect of an Intervention Based on Multisensory Environment for Proprioception Assessment in Children With Down Syndrome: Case Study.
05	2021	Panceri, J. A. C., Freitas, É., de Souza, J. C., da Luz Schreider, S., Caldeira, E., Bastos, T. F.	A New Socially Assistive Robot with Integrated Serious Games for Therapies with Children with Autism Spectrum Disorder and Down Syndrome: A Pilot Study.
06	2019	García-Ruiz, M. A., Santana-Mancilla, P. C.	Towards a usable serious game app to support children's language therapy.
07	2020	Nüssli, S., Schmidt, T., Denecke, K.	How to Motivate Children with Severe Disabilities to Adhere to Their Therapy?.
08	2020	Ou, Y. K., Wang, Y. L., Chang, H. C., Yen, S. Y., Zheng, Y. H., Lee, B. O.	Development of virtual reality rehabilitation games for children with attention-deficit hyperactivity disorder.
09	2013	Høiseth, M., Giannakos, M. N., Alsos, O. A., Jaccheri, L., Asheim, J.	Designing healthcare games and applications for toddlers.
10	2012	Oikonomou, A., Day, D.	Using serious games to motivate children with cystic fibrosis to engage with mucus clearance physiotherapy.
11	2015	Muñoz, J. E., Lopez, D. S., Lopez, J. F., Lopez, A.	Design and creation of a BCI videogame to train sustained attention in children with ADHD.
12	2016	Wang, I. F., Wang, D., Chen, C. Y., Jheng, J. F.	PinchFun: A Fine Motor Training Game for Preschool Children with Developmental Delay.
13	2016	Lopes, M., Magalhães, J., Cavaco, S.	A voice-controlled serious game for the sustained vowel exercise.

2.2 Data analysis

The data analysis was performed by three members of the team in a collaborative way. To facilitate the analysis, we created three paper-based visualisation tools inspired by board games: case study cards, game sheets, and a visual timeline of the design process. The ID numbers of the selected records were reported in each visualisation tool. Since the data extraction and analysis is the challenging phase of the systematic literature review [36], such visualisation tools supported us to summarise the most relevant information, share the knowledge among the team, and collaboratively identify patterns and key lenses for the interpretation of the results.

Case study cards. These cards contain the essential information about the case studies reported in the selected records, using a colour code to facilitate the clustering process (Figure 2): a) the blue cards provide information about therapy context; b) the purple cards provide information about the patients; c) the pink cards provide information about the gamification mechanisms; d) sky blue cards provide information about the game platform and device. We created 70 case study cards to report all the relevant information about each selected record.

Fig. 2. Case study cards created to facilitate the data analysis process.

Game sheets. Like the character sheets used in some board games, we created the game sheets to describe the key characteristics of the game or game mechanism employed in the therapy, as reported in the selected record. As shown in Figure 3, the game sheet is divided in two section: on the left side, there are the information related to the selected record (year, title, keywords), the name of the game and its features (objectives related to the therapy and gameplay); on the right side, there are representative images of the game environment, characters or dynamics. We created 13 game sheets, one for each selected record.

Fig. 3. Game sheet created to facilitate the data analysis process.

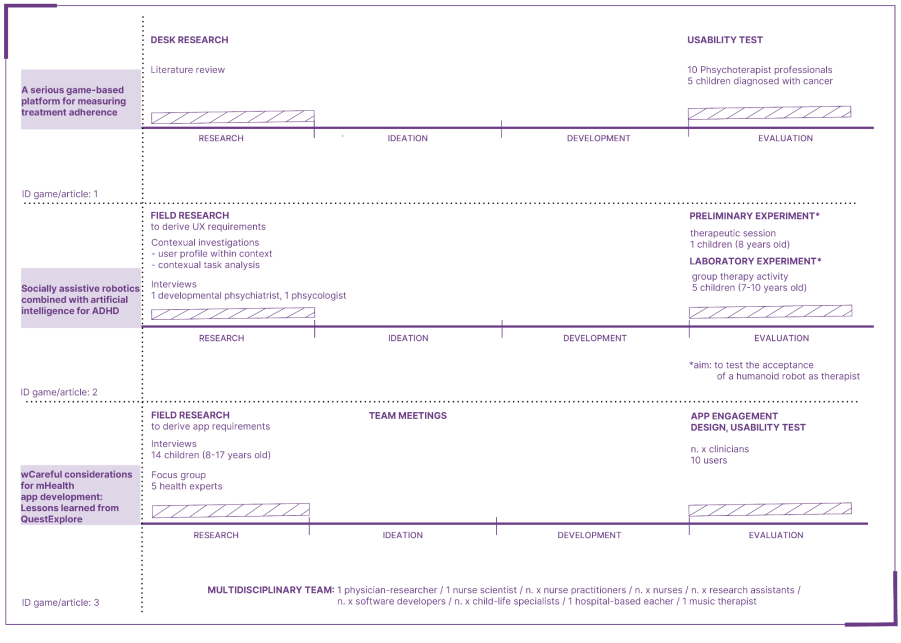

Fig. 4. Visual map of the design process created to facilitate the data analysis process.

Visual timeline of the design process. To integrate the data and have a clear picture of the design approaches in terms of methods and participants involved, we created a visual map (Figure 4). It represents a timeline with four segments (research, ideation, development, evaluation), and for each segment it reports the information about the methods employed in the selected records: e.g., distinction between primary-source data or secondary-source data, evaluation methods, as well as the number of testing sessions and participants.

One member of the team created the case study cards, the game sheets, and the visual map of the design process, while the other two members of the team checked these visualisation tools to ensure they contained all the correct and necessary information to support the analysis according to the RQs. Then, to collaboratively perform the analysis, we arranged the visualisation tools on the table to create some clusters based on similarities and differences among the selected records, for each RQs. Once all clusters were formed, we spent time discussing possible connections between the diverse RQs and clusters.

3 Results

In what follows we illustrate the results by addressing each RQ. We therefore explore the application contexts of the gamification strategies together with their purposes (RQ1), and the expected impacts in terms of therapy experience and compliance (RQ2). The analysis of the gamification strategies is based on the gamification features introduced in the therapy contexts (RQ3), and then the design approaches are discussed according to the process and stakeholders' roles (RQ4). Along with the analysis of the results, technology-related aspects clearly emerged as a relevant topic also to be explored, to develop a comprehensive overview of the use of gamification in therapeutic contexts.

3.1 RQ1: Which therapies make use of gamification mechanisms?

Considering the therapy interventions and the target population, the selected papers were categorised in three kinds of treatment that employ a gamification strategy, based on the classification and terminology of the World Health Organisation: most of the selected case studies address rehabilitation therapy (8 out of 13), followed by pharmacological treatment (4 out of 13), and corrective therapy (1 out of 13). Only one case study (ID07) can be applied to diverse interventions ranging from physiotherapy to occupational therapy.

This categorisation of the therapy contexts is essential to understand the application domain and the potential benefits of introducing game mechanisms as means to stimulate the compliance.

Rehabilitation therapy. Rehabilitation therapy includes a set of interventions designed to optimise functioning and reduce disability in individuals with health conditions in interaction with their environment [40].

- Speech and language training aims to improve a person's communication skills (ID6 and ID13 for children with language disorders).
- Physical exercises are intended to improve motor coordination, fine movements, balance and proprioception (ID04, ID05, ID08 for children with Down Syndrome, autistic spectrum disorder, attention deficit hyperactivity disorder, ID12 for children with developmental delay).
- Social skills training is a type of behavioural therapy to improve the abilities and gain confidence when interacting with other people (ID02 for children with attention deficit hyperactivity disorder).
- Cognitive training aims to increase basic cognitive abilities like planning tasks and following instructions (ID11 for children with attention deficit hyperactivity disorder).

Rehabilitation therapy is highly person-centred since the intervention is tailored to each patient and to the context (e.g., at home, in hospital) [40]. From the patients' point of view, the therapy might be repetitive and lengthy, and the exercises to perform might be painful. These negative aspects of the therapy experience motivate the introduction of the gamification mechanisms.

Pharmacological therapy. Pharmacological therapy employs pharmaceutical substances (drugs or medications) to treat, manage, or prevent various medical conditions. The compliance for this kind of therapy, to follow the medication regimen taking into account the frequency and timing of administration, is essential also for preventive treatments [22].

ID09 and ID10 address respiratory interventions, ID01 and ID03 address cancer treatment in therapeutic programs with multiple interventions (medication, physiotherapy, diet). In these cases, the compliance with the therapy is more challenging and it often requires periods of hospitalisation, causing high levels of emotional distress. The stimulation of compliance in the context of pharmacological therapy appears as a relevant application domain for the game design.

3.2 RQ2: What are the expected impacts in terms of compliance from the implementation of gamification mechanisms in the therapy?

By analysing the goals of the selected case studies, a broad range of purposes have been pointed out. For each goal, an example is provided to discuss the expected benefits from the point of view of the patients and the other stakeholders.

In some cases, the gamification aims to directly impact the compliance with the therapy, for example for practising abilities and stimulating healthy behaviours. In other cases, the gamification affects the compliance indirectly by making the therapy enjoyable, increasing the knowledge about the disease and the therapy, connecting the patient with other people (Figure 5).

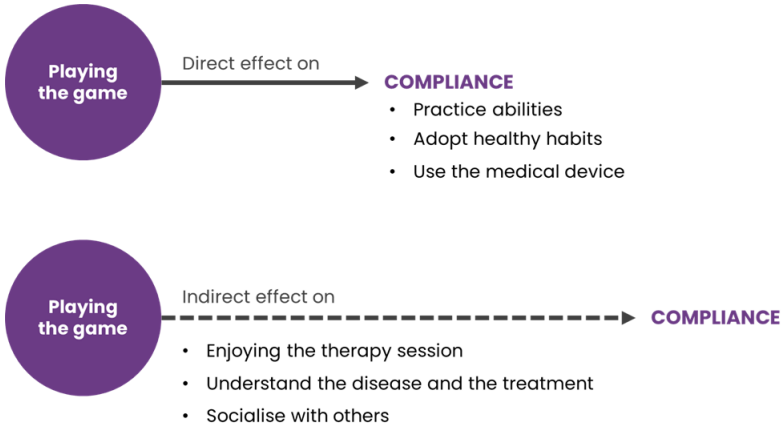

Fig. 5. Visual representation of the direct and indirect effects of playing the game on compliance.

Practising abilities. Most of the selected case studies (8 out of 13) employ games to enable the children to develop abilities at cognitive, motor or social level according to the rehabilitation protocols. Taking advantage of innovative technologies like embedded sensors and cameras, the children interact with the game based on the real-time movement analysis. In this case, the game is a tool that mediates between the patient and the therapist providing instructions and feedback.

For example, one of the task-oriented scenarios included in ID04 enables children to train their vestibular and proprioceptive systems by using their bodies to control the game character shown on the screen. A multimodal system is implemented to combine auditory and visual feedback, while the body movements serve as input to interact with the game.

Presenting the therapy tasks as games facilitate the acceptance of the therapy as a familiar context for the children since the games are part of their everyday life.

Thus, in this case the compliance corresponds to following the instructions and performing the therapy-game tasks as expected by the therapy protocol. This stimulates the experience of competence, mastery and effectiveness when the patient solves the game challenges and progresses both in the game and in the therapy [30].

Stimulating healthy habits. This goal is not specifically related to the treatment protocol, but it addresses the need for adopting healthy behaviours to improve the general health status and to achieve the therapy outcomes.

This is the case of the game of ID01, designed for children undergoing cancer treatment to stimulate the adoption of habits related to hygiene, nutrition, and physical exercises. Such behaviours integrate the pharmacological treatment, and they are essential to better face possible negative side effects of the therapy [5, 3]. Considering this objective, the compliance is related to the adoption of healthy behaviours in different areas, as a combined effort to improve the health status.

Making the therapy session enjoyable. This objective is mentioned in 7 out of 13 selected records, those which address long-term rehabilitation therapies with repetitive and boring tasks to perform during each session [ID02, ID05, ID07, ID08, ID09, ID09], as mentioned in the previous paragraph. The goal of the gamification is to make the therapy more attractive and to stimulate positive emotions like joy and surprise during the sessions.

In ID09, the attempt to transform the therapy session into a playful moment is due to the characteristics of the patients who are toddlers with respiratory disorders, and due to the characteristics of the nebuliser treatment. Indeed, the patients receive medications through a mask that covers the mouth and the nose, the treatment lasts for 5-10 minutes during which the patients must sit still, and the session is typically repeated every 2-4 hours in a clinical setting. The issues reported by the authors are several: the mask is uncomfortable, the mask and the noise produced by the device are perceived as scary by the patients, and the mist smell and taste odd.

To address these issues, the game is played during the therapy sessions by the patients and the parents together, to help the game character during its journey. The game is a means to distract the attention of the patients and to focus their attention on the game while waiting for the session to end.

Thus, in this case the game stimulates the compliance indirectly by making the activities required by the therapy fun and enjoyable to perform. This increases the intrinsic motivation since the patients engage in the therapy session because they enjoy it and get personal satisfaction from doing it.

Increasing knowledge about the disease and the treatment. When the young patients suffer from chronic conditions with multiple symptoms and comorbidities, understanding the disease, how it progresses and the factors affecting the health status is challenging for the patients. To this end, the gamification mechanisms can be employed to stimulate the patients in monitoring and understanding their status.

This is the case of ID03 that experimented with a game for daily reporting the symptoms, the medical interventions and the patient's mood. The data collected in the "Symptom Journal" are available for the clinicians to monitor the therapy, and this aims to facilitate the communication with the patients.

The goal of increasing knowledge is also mentioned in ID09: in addition to the interactive game tailored to the patients, the application includes educational contents about the treatment that the caregivers can use to increase their knowledge and to facilitate the meaning-making process of the children.

As for the previous objective, the compliance in this case is stimulated indirectly by increasing the awareness about the benefit of the therapy and about the role of the patients in achieving successful outcomes.

Connecting with others for social interaction. The games can serve to create connections with playmates who can be the caregivers or other peers with the same medical condition. For example, in ID09 the game is designed so that hospitalised children can play together even though they are in isolated rooms. In addition, games can support social activities by including elements that are more directed towards the caregivers with the intention to trigger dialogues with the children.

In this case, the gamification does not directly impact on the compliance with the treatment, but it aims at creating the favourable conditions for the acceptance of the therapy and the compliance. From a game design perspective, this strategy stimulates the feeling of relatedness through social connection, competition and cooperation [30].

Facilitating the acceptance of medical devices. Another goal that could be achieved through the gamification is the acceptance of the medical devices. This is exemplified by ID09 that addresses the issues related to the nebulizer device that the young children must use in case of inhalation therapy, suffering from emotional distress during the treatment.

The game is designed to engage children and parents in a playful journey which lasts as long as the nebulizer treatment, and to reward the children when they comply with the entire therapeutic session. In this case, the strategy relies on extrinsic motivation: the compliance with the therapy is achieved because the patient uses the medical device as required to gain the rewards of the game.

Therapy supervision. Therapy supervision aims to increase clinicians' awareness of the therapy progress and to enable therapy self-management [ID01, ID03, ID04, ID05, ID10, ID11]. From an overview of the selected records, supervision is another emerging key challenge in a therapy context as it provides experts with relevant information about the therapy progress for ongoing changes in the therapeutic plan.

To increase clinician awareness, interventions can be classified into two clusters by evaluating the place of the monitoring activity. The first one relies on contextual monitoring activity which calls for the simultaneous presence of the therapist and the patient. For example, ID04 considers the implementation of a multi-perspective video camera system to make the analysis of child's movements automatic, to help therapists in collecting dependable data.

The second cluster of interventions collect data remotely, which means that the therapists control the therapy progressions or compliance levels in a time frame different from the gamified therapy execution. ID10 monitors various metrics including the duration of time spent on each game, the frequency of play, the time allocated per game, as well as mask wear-time and the volume of air exhaled by individual users.

ID11 uses neurofeedback, biomarker for tracking user's performance. In addition, an algorithm for the calculation of the Theta/Beta ratio inside the engine of the videogame was developed using the EEG signal that was registered in the central part of the front lobe of the brain during the interaction with the videogame.

3.3 RQ3: According to the specific treatment protocol, what are the gamification mechanisms implemented in the therapy to facilitate the compliance?

To answer this RQ, we analysed the characteristics of the gamification strategies according to game taxonomies [29, 15] and with the lenses of the patients' compliance with the specific treatment practices. Some gamification mechanisms are widely used in the selected case studies, while other mechanisms are neglected or purposefully avoided because of the therapy purposes.

Reward dynamics. Although the selected records included a broad range of game mechanisms, the overall trend is the use of reward dynamics which are employed in 9 out of 13 selected records. The goal is to stimulate the children to collect numerical values as reinforcement for their commitment, effort, and achievements in the therapy. These values assume different forms (e.g., coins, badges, stars) and dynamics (Figure 6).

ID06 provides children with virtual tickets to play carnival games, when they demonstrate their improved language skills. This kind of reward can be classified as Reward of Access to unlock game resources [29], and it is provided for therapy-related achievements.

ID03 provides children with incremental badges when they accomplish goals, and this kind of achievement can be classified as Reward of Glory [29] . In this case, the rewards are provided both when the player reports their status in the "Symptoms Journal" (therapy-related achievements), and when they interact with the game contents (in-game achievements).

ID01 rewards the in-game achievements when the game character (a virtual pet) controlled by the player performs healthy habits such as good hygiene, following medical prescriptions, and practising sports. The coins collected can be spent to improve the game characters as a form of Reward of Facility, or to unlock mini games as a form of Reward of Access [29]. In this case, the persuasive strategy is to stimulate the children to behave like the virtual pet that is rewarded for its achievements.

To sum up, the rewards are widely used in the selected records and they are intended to reinforce the compliance with the therapy (e.g., use of the nebulizer device in ID09), or to reinforce positive behaviours for improving the health status of the patients (e.g., healthy nutrition habits in ID01), or to recognize in-game achievements and promote the engagement with the game.

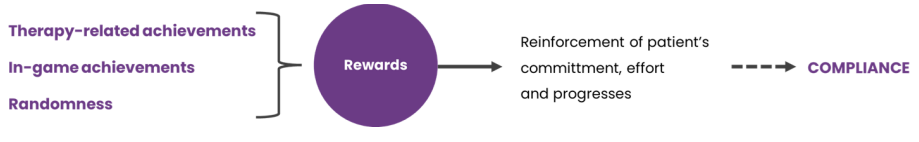

Fig. 6. Visual representation of the reward dynamics used to stimulate the compliance.

Aversion and Randomness. Together with the reward dynamics, the game taxonomy includes the dynamics of punishment when the player receives penalties [15]. This dynamic is not reported in the selected records, and in ID05 the authors clarify that "they did not use any form of punishment in the game to avoid aversive feelings such as frustration and anxiety" [27]. This design choice might be motivated by the characteristics of the target users who are fragile children undergoing healthcare treatment for temporary or chronic conditions. Introducing punishments in the game might represent a hindering factor that limits the compliance with the therapy.

Another game dynamic that is overlooked (mentioned only in 1 out of 13 selected records) is the randomness. This feature makes the game unpredictable since the rewards are set for free, or because the result of an event is not affected by the player's actions [15]. Since the games relate to the therapy and the health status of the patients, introducing these kinds of unpredictability seems counter-productive. While other

forms of randomness could be introduced to stimulate players' curiosity and surprise: when the context is always changing, when the players receive special customisation rewards or discover hidden elements, the game routine is broken and the interest towards the game is renovated, especially in the case of long-term treatment.

Incremental levels. The game dynamic related to the incremental levels of the gameplay represents a relevant strategy to motivate the patients (Figure 7). It is employed in 6 out of 13 selected records.

ID05 provides an example of how to connect the gradual increase in the difficulty level of the game with the progress of the therapy. Specifically, the game aims to train children's balance, proprioception, and motor coordination by challenging their abilities with increasingly difficult motor tasks to perform. The entry level of the game corresponds to the initial period of the therapy, when the abilities of the patients are low. During the therapy the abilities improve, and the game challenges them with more difficult tasks. Such dynamics is fundamental when the treatment protocol includes incremental levels and, as reported by the authors, it is a valuable strategy to reduce patients' anxiety.

Another motivation to introduce different game levels is based on the patient's profile: in ID07, the progress of the game character during its journey is varying and it does not only depend on the motivation, but also on the physical condition of the patient.

Fig. 7. Visual representation of the game levels used to reinforce the therapy progress.

Role and Narrative. The immersion-related mechanics which emerged the most are primarily two, namely role and narrative.

Some gamification strategies are based on avatars controlled by the players. The goal is to create the conditions for the vicarious learning since the avatars act as positive models to mimic [15]. An example of this strategy is provided by ID01 in which the game characters (a virtual pet) resemble the reality of the patient in order to stimulate the adoption of healthy behaviours: in the kitchen, the refrigerator contains foods that can affect the health status of the character, the pharmacy offers medicines that allude to the drugs taken by the child; the everyday life of the virtual pet includes hygiene practices, sports and sleeping.

The other immersion-related mechanism is the narrative: a story that connects the game (with its characters, challenges, and environment) with the patient and the therapy. While a trend of the selected records is to use mini games, another trend is to create a journey into the game story that progresses with the therapy. In ID07, role and

narrative are integrated to support the compliance in the context of therapies lasting for a prolonged period. For example, the adventures of the game character Teddy are enabled by the patient who collects experience points during the therapy, and thus the journey of Teddy corresponds to the journey of the patient during the therapy.

Challenges and Quest. According to the taxonomy of Hervás et al. [15], the game can be designed to include challenges that the player must overcome, or the quests that need to be solved in a collaborative or competitive way. Considering the selected records this distinction is not evident.

We assume that most of the selected records employ challenges and individual use of the game, while ID12 specifically designed the quests since two players need to cooperate to control the game character and collect the rewards. This is possible since the two players attend the same rehabilitation sessions and use the game controllers to train the fine motor skills. Further investigation is needed to understand the opportunities and requirements to design game quests for the therapy.

3.4 RQ4: What roles do the end users and other stakeholders play in the design process?

Most of the selected records do not deepen the discussion of the design approach since the focus is mainly on the design output.

Based on the segmentation of the design process into four phases, the research phase aims at framing the problem and identifying the requirements, the ideation phase conceptualises the solution, the development phase creates the prototypes, the evaluation phase aims at assessing the proposed solutions.

Considering the research phase for problem framing, 4 out of 13 selected records employed desk research methods to investigate the problem through secondary-source data, 6 out of 13 selected records employed field research methods to collect primary-source data from the stakeholders (e.g., interviews, focus group), 3 out of 13 selected records combined desk research and field research, while only one selected records does not report any research methods employed in this research phase.

While the desk research is useful to frame the problem and identify best practices based on the scientific literature, the field research is essential to deeply understand the perspectives of the stakeholders, not only the patients but their caregivers and the healthcare professionals. Notably, two case studies [ID10, ID11] established multidisciplinary teams in which the stakeholders are actively involved in the design process together with the design professionals.

Considering the ideation phase, only 1 out of 13 selected records specify the process leading to the conceptualisation of the gamification strategy: ID09 collected various insights from the workshops with the stakeholders, and an affinity diagram was used to integrate and categorise the ideas. This phase laid the groundwork for prototyping the game application.

Considering the development phase, the selected records do not describe the prototyping of the solutions. They only provide information about the platforms and devices used to play the game.

Considering the evaluation phase, 10 out of 13 selected records describe the goals, methods and participants involved in this phase. We point out two tendencies.

In some cases, the evaluation is focused on usability and user experience, and it is carried out through user testing sessions with patients and healthcare professionals. For example, ID01 involved a group of psychotherapists in usability testing during which they evaluated the interaction flow and interface elements of the game. The objective of this evaluation is to identify usability problems, to inform the re-design of the game.

In other cases, the evaluation is performed in the operational environment where the gamification strategy is experimented to assess its impact on the therapy. For example, ID04 integrated the game into the therapy protocol for three patients, and the goal of this experimentation was to demonstrate the efficacy of the game in improving the proprioception abilities of the patients.

Looking at the roles played by the stakeholders, we highlight diverse approaches ranging from informative role when the users act as source of information and objects of investigation, consultative role when they evaluate predefined design solutions, to participative role when they actively take part in the decision-making process about the project solutions [7] (Figure 8).

Fig. 8. Visual representation of the design phases and role of the stakeholders.

Nowadays it is acknowledged that the technological innovation in the healthcare domain should be led by multidisciplinary teams, combining diverse points of views, preferences, and domain expertise to disentangle the requirements [4, 21]. This multidisciplinary approach is not free from any issues, even though the selected records do not discuss this aspect. We expect that the collaboration is challenging especially in the case of complex therapies performed by a team with nurses, psychotherapists, physicians, in collaboration with the patients and their parents, like in the case of ID01 and ID03. Further investigation is needed to focus on the process leading to the design and evaluation of the gamification strategies.

3.5 Therapy-oriented technology

Several authors explicitly declare that one of the proposed goals is to experiment with technological solutions in therapeutic contexts. Starting from this statement, we analysed the selected records by classifying each game design case into two categories: analogue and digital games. The results showed that every gamified therapy presented in the selected records rely on technology in different ways and none of them is an analogue game (e.g. board games). To frame the use of technology in gamified therapy-related interventions, two main purposes can be identified: technology used for the therapy supervision, technology used to play the game.

Technology for therapy supervision. Some technological solutions represent an essential requirement to allow therapists in collecting significant information about patients' health conditions and/or their compliance to therapy. To this extent, three technology dimensions have been identified:

- Social Assistive Robots (SAR) are emphasised as significant tools in ID01 and ID05 both for contextual and remote supervised therapeutic contexts;
- Virtual Reality is the technology that ID04 and ID08 employed to create an immersive scenario where therapists can monitor the patients during the therapeutic sessions;
- Screen-based technology is implemented in most of the selected records (10 out of 13) and refers to the development of software that can be played through computer, smartphone or tablet. This technology demonstrates to be suitable both for on-site and remote supervised therapeutic contexts.

Therapy supervision is particularly important in case of remote supervision as therapists must find a way to obtain reliable data in out-of-control contexts. In this scenario, screen-based digital games represent a valuable resource as they can track patients' behaviours and habits.

While ID03 relies on patient-generated content as it invites children to report their symptoms, mood, and medical interventions daily to derive therapy trends and patterns, ID01 and ID02 aim at monitoring children's emotional state through systems of automated-generated contents which derived data from video recordings of children-game interactions.

Technology for game interaction. As stated before, each selected record develops a digital gamified intervention which can be clustered according to the design of the children-game interaction and the related interface.

The touch-screen user interfaces are prevalent in mobile gaming, and this reflects in the predominance of this kind of interaction among the selected records. For instance, in ID06, children are prompted to choose the correct option either by clicking or typing it, whereas in ID02 a humanoid robot is equipped with a touchscreen interface enabling interaction with patients via the application.

The gesture-based interfaces are primarily implemented when the patients engage with the game through gestures, motions, or movements to control characters or manipulate objects within the game environment. In ID08 patients use hand gestures or body movements as they must catch fish flying overhead while simultaneously avoiding birds swooping towards them.

Another significant way of engaging with the digital game involves the use of a physical controller which mirrors the actions of patients on the screen. This is exemplified in ID12, where children manipulate the movement and velocity of the avatar, or accurately time a pinch gesture to gather gifts.

Voice is an alternative method to perform actions in the game. In ID13, a Voice User Interface (VUI) has been designed to enhance sustained vowel exercises. By maintaining the vowel at the appropriate intensity, children gain the ability to propel a bird towards its nest.

Finally, just one selected record experimented with a Brain-Computer Interface (BCI) that is an emerging technology allowing players to control characters or interact with virtual environments using their thoughts. ID11 aims at training waiting, planning,

and perseverance ability by using attention levels of children with ADHD as mental controllers of the mini games.

4 Conceptualising therapeutic games and games for therapy

From the analysis of the selected records, we derived a main conceptual distinction between “therapeutic games” and “games for therapy”. This distinction has diverse implications in terms of design and impact, as described below.

The therapeutic games transform the therapy tasks, like rehabilitation motor exercises, into playful game challenges. The compliance with the therapy corresponds to playing the game, following the instructions to perform the tasks, and achieving the expected progress over time.

It is acknowledged that a negative experience during therapy exercise with pain, boredom, and lack of enjoyment is a barrier that prevents the compliance, especially in long-term therapy [31, 17]. Thus, the strategy to increase compliance is based on the positive enjoyable experience enabled by the game. In this case, the game is part of the therapy protocol and for this reason the game design is strongly connected to the therapy protocol.

For example, the design of the games used in ID05 to develop the coordination abilities of the children is based on the motor exercises required by the rehabilitation protocol. The use of sensors and cameras enables real-time monitoring and feedback, and the use of diverse difficulty levels tailors the task to the patient's profile, to incrementally challenge children’s abilities.

Another common characteristic of the therapeutic game is the integration of different mini games to develop specific abilities, and the use of body movements and positions as input to interact with the game environment and characters. This latter feature requires specific equipment to collect accurate data and elaborate them in real time.

The “games for therapy” are additional resources to be used alongside the therapy protocol. The game design should establish a connection between the game and the therapy, but the game play, the environment, and the dynamics can address very different themes. The impact on the compliance is indirect since the game aims at establishing the facilitating conditions to adhere to the therapy protocol. For example, the design of the game used in ID09 addresses the experience of the patients during the sessions of the nebuliser treatment in hospital settings. The goal is to distract the patients by shifting their attention from the nebuliser mask to the game.

Identifying common characteristics of the games for therapy is more challenging since the design process is less restricted by therapy protocols and requirements, compared to the therapeutic games. Nevertheless, from the comparison between the two concepts, some patterns appear evident (Figure 9).

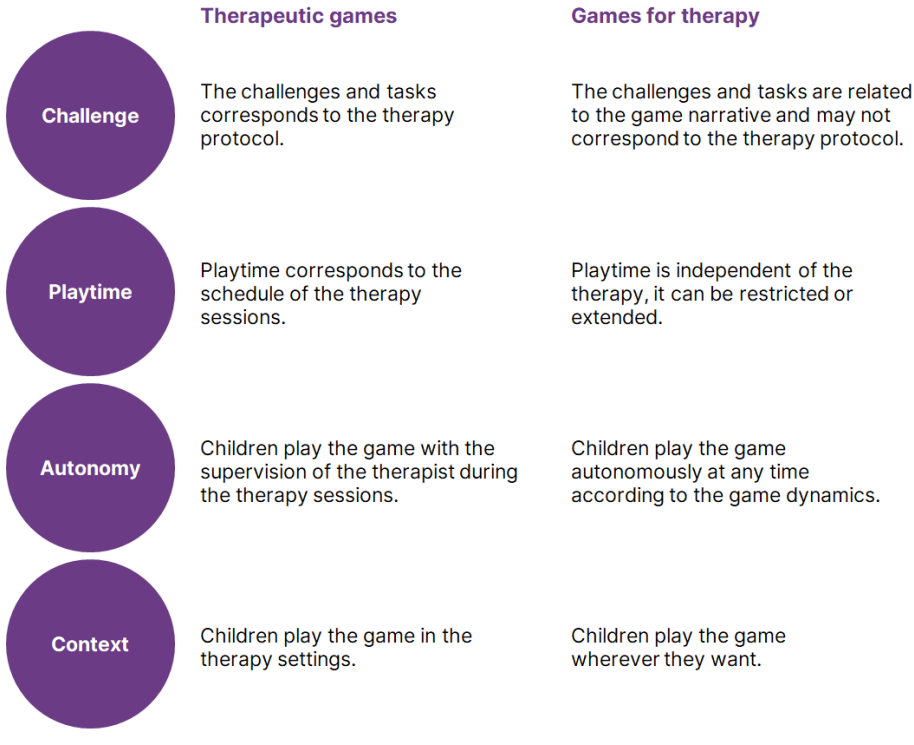

Fig. 9. Patterns identified based on the conceptual distinction between therapeutic games and games for therapy.

The distinction between therapeutic games and games for therapy is useful to categorise the state of the art and to guide the future design practice, given the heterogeneity of concepts available in the literature (e.g., serious game, game for change, gamification). Since it is a conceptualisation, it does not match all examples perfectly, especially when considering the autonomy of the player and context of the game. Considering this, the conceptual model should be considered as a lens to understand how the challenge, playtime, autonomy, context, and game mechanisms can be designed to achieve specific impacts on the compliance.

First, the playtime and game exposure should be considered as a critical factor. While in the case of the therapeutic games the playtime corresponds to the schedule of the therapy sessions and it is often supervised by the clinicians, in the case of the game for therapy the playtime is designed independently from the therapy schedule, and it is often autonomous. Notably, the selected records do not critically discuss benefits and risks of the exposure to the game, while the scientific debate pointed out the need to reflect about this issue (e.g. [14]).

Another implication coming from the distinction between therapeutic games and games for therapy is related to the evaluation of the impact. Only a few cases among the selected records validated the gamification strategy in the operational environment.

The tendency is to organise evaluation sessions focused only on the usability and user experience of the game.

In case of therapeutic games, the clinical trials are essential to validate the gamified therapeutic protocol. While the games for therapy can benefit from clinical trials to assess the indirect impact of the game on the patients' level of compliance. Further investigations are needed to fill this gap.

When these treatments deal with children with chronic diseases, difficulties arise as an ever balanced and personalised therapeutic plan must be released without having real-data access. To gather this kind of information children as patients have a key role and symptom reporting is essential. ID01 reflects on the usefulness of mobile apps as a medium to collect data and on their attractiveness from a more engaging perspective. On the other hand, handling emotional distress during long term treatments is a challenge, particularly when the patients are very young (1-3 years old).

5 Limitations of this study

This study was performed focusing on specific gamified strategies used to stimulate children compliance with therapy. The data collection was limited to the research articles identified on five databases, which may result in the omission of some relevant articles not included in these databases. Other relevant articles may be not considered due to the lack of free access to full texts.

Moreover, the data analysis was performed on the information available in the selected records, with no reference to other documentation sources (e.g., projects websites, project reports, grey literature etc.). This may lead to the exclusion of relevant projects in this domain because they are not reported with sufficient details in the screened records.

6 Conclusions

This paper focuses on gamification strategies to improve children's compliance with pharmacological and non-pharmacological treatments, to guide the future design practice. This objective is motivated by the need to map the state of the art on this topic from a game design perspective.

The systematic literature review was performed using five databases and it led to the selection of 13 records among the 530 records retrieved from the databases. The selected records cover diverse gamification strategies and therapeutic contexts, and to deal with such complexity we analysed the data using three visualisation techniques to synthesise the knowledge and to identify patterns.

The results point out a fundamental distinction between two gamification strategies. The "therapeutic games" transform the therapy exercises into game challenges which directly impact the health status of the patient; they are usually played with the supervision of the therapist and within the therapy setting (e.g., at the hospital). In this case, the compliance is stimulated by offering an experience that is fun and familiar for the children.

The “games for therapy” are playful resources used in addition to the therapy protocol; they can be played autonomously by the children without the need to be in a specific context. In this case, the compliance is stimulated by connecting the therapy progress with the game rewards and dynamics, leveraging on the extrinsic motivation.

While the therapeutic games are designed according to specific therapy protocols, the ideation of the games for therapy is not restricted by the therapy protocol.

Beside this conceptual distinction, there are some open issues that should be considered when designing gamification strategies for children in therapeutic contexts. The objective of this paper is to stimulate the reflection on these open issues.

- One open issue is related to the playtime, to avoid the prolonged exposure to the game while assuring the positive impact of the game on the patients’ health status.
- Another design challenge is related to the aesthetics of the game characters and environments, to meet the preferences of children of diverse ages, gender and cultural background. This is even more challenging if we consider that the children's preferences change over time.
- When the goal of the game is to provide a positive model to mimic, we need to design the elements that stimulate the identification of the player with the game character.
- Especially in the case of long-term treatment, the game should remain interesting and engaging over time to achieve its impact. This requires carefully designing the game narrative, challenges, elements of randomness for surprise.

In addition, the results of the systematic literature review showed that technology innovation in therapy plays a key role. The main reason relates to the objective of therapy supervision. However, even the selected records which do not plan to monitor patients’ activity develop technological solutions to interact with the game. As framed in the discussion of the results, in the selected records little attention is devoted to examining the efficacy of employing gamification for therapeutic purposes. This lack of appropriate inquiries could prompt interesting studies about the comparative impact of technological solutions compared to traditional analogue tools on effectiveness. Matching this with the absence of systematic studies about the effectiveness of gamified interventions, it represents a stimulating insight to guide future explorations to get a more comprehensive understanding of how technology and therapy interact with each other in terms of impact.

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