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The use of Matti: a tangible user interface in physical rehabilitation to motivate children and older adults

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Abstract: Highly motivated patients who enjoy their physical rehabilitation tend to attain better therapeutic outcomes. However, given the prolonged repetitive nature of postural control rehabilitation in older adults and children with developmental coordination disorder (DCD), motivation levels might drop quickly. Exergames and digital therapy tools could offer practical answers to this issue and allow therapists to provide patients objective outcome measurements. To incorporate digital innovation in clinical and rehabilitation practices, this study discusses Matti, an interactive system created as a customisable tangible user interface (TUI). Its usability in pediatric and geriatric physiotherapy contexts is explored and evaluated through user evaluation. The Matti device was found to be usable and enjoyable for exergaming rehabilitation. However, additional study on measuring capabilities is needed to enable the accurate and reliable objective outcome measurements through this TUI. Future research should analyse how this TUI and gamified postural control assessment affects patients' motivation and therapeutic outcomes.

Keywords: children; exergames; older adults; rehabilitation; tangible user interface; TUI.

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1 Introduction

Being independent and mobile, including maintaining one's balance, is vital for an individual's perceived quality of life (WHO, 2004). However, this might be challenging for children and older adults with balance and postural control deficits. Approximately one in every twenty children (aged 3 to 17) suffers from 'dizziness' or 'imbalance' (Li et al., 2016). The developmental disorder known as developmental coordination disorder (DCD), which significantly affects day-to-day living activities, is one possible medical diagnosis for this condition (American Psychiatric Association, 2013). Although children with DCD might have a wide range of motor skill deficiencies, instability, unsteadiness, and lack of coordination are frequently observed.

Postural control deficits and an increased risk of falling are also common among older adults. According to research, one-third to half of the population will face these problems at some point in their lives (Rubenstein and Josephson, 2002). Age-related declines in sensory systems (e.g., vision, proprioception), a reduced ability to adapt to changes in their environment, and a more variable and slower gait are all factors contributing to these high numbers (Kim, 2021; Osoba et al., 2019).

Physical rehabilitation is often used to treat illnesses, injuries, and conditions that limit a person's mobility. To regain or improve certain functions, patients are frequently required to perform training exercises repeatedly and over a long period of time. This requires a significant amount of individual effort and cooperation from the patient. Thus, patient motivation becomes a critical factor in maintaining the required levels of therapy compliance. According to recent research, highly motivated patients have better outcomes than less motivated ones (Meyns et al., 2018). As a result, it is critical to keep patients motivated during the rehabilitation process, especially when children with DCD and older adults with postural control deficits may require years of frequent therapy.

The use of interactive systems as a training platform has been considered to maintain and improve patients' motivation during rehabilitation. Many different types of interactive systems have been developed to support a wide range of rehabilitation programs. Some of these systems are designed specifically to encourage, improve, or maintain a patient's motivation throughout the rehabilitation process. Serious games, virtual reality applications, interactive collaborative environments, and tangible user interfaces (TUI) are just a few examples.

The development of new rehabilitation systems based on the TUI approach is considered promising because these devices are more intuitive and accessible for patients with limited technological experience (Marshall et al., 2007). Additionally, the use of video games in clinical or rehabilitation settings has also received a lot of attention. The use of gaming elements in rehabilitation has been shown to increase patient enjoyment. By providing feedback on their performance, they also help to maintain higher levels of interest during exercise regimes (Colombo et al., 2007).

Exergames, which receive input directly from the players' movement, have piqued the scientific and physical therapist communities' interest. Previous research on the effects of rehabilitation interventions with commercially available exergames has shown small but positive indications of their supplementary use in clinical practice (Bonnechère et al., 2016). According to both researchers and therapists, the main disadvantage of using these tools in general is their lack of adjustability. Serious exergames, which are games designed for a purpose other than entertainment, may provide therapists with the necessary level of control. To make these tools truly relevant and applicable in daily practice, physical therapists must begin collaborating with game developers and engineers (Bonnechère et al., 2016; Eriksson et al., 2021). Collaboration between these groups may also improve clinical professionals' attitudes toward the concept of serious games in their practice.

How can we help people with postural control and coordination deficits by engaging them in motivating physical rehabilitation? With its interactive surface and tailored therapeutic exercises in the form of exergames, Matti serves as a training platform for this purpose. In this paper, we discuss two user studies with DCD children and older adults to investigate the potential of Matti to effectively influence their motivation during their rehabilitation process.

2 Motivation and enjoyment in rehabilitation

Key factors to an effective and successful rehabilitation are repetitive, functional, and task-specific exercises performed with high intensity and duration (Bütefisch et al., 1995; Kwakkel et al., 2004; Sunderland et al., 1992). Therefore, in most cases, rehabilitation training exercises generally involve performing the same movements repetitively and over a long period of training time. However, this may result in the sensation of a monotonous rehabilitation or even boredom (Bracke et al., 2006). To avoid this effect and achieve good rehabilitation outcomes, it becomes necessary to maintain patient motivation, cooperation, and satisfaction during training (Järvikoski et al., 2013; Maclean et al., 2000). Previous research has shown a clear link between patient motivation and its effect on the rehabilitation of patients suffering from stroke (Maclean et al., 2000), acquired brain injury (Mutchnick, 1988), schizophrenia (Saperstein and Medalia, 2015), children and adults with cerebral palsy (Tatla et al., 2013), DCD (Sims et al., 1996) and older adults (Vanroy et al., 2019). These studies confirm that patient motivation significantly affects rehabilitation outcomes. One possible explanation is that rewarding and motivating therapy stimulates dopamine release, which in turn enables better neural plasticity and (motor) learning through long-term potentiation of synaptic connections (Bao et al., 2001).

2.1 Self-determination theory as framework for motivation

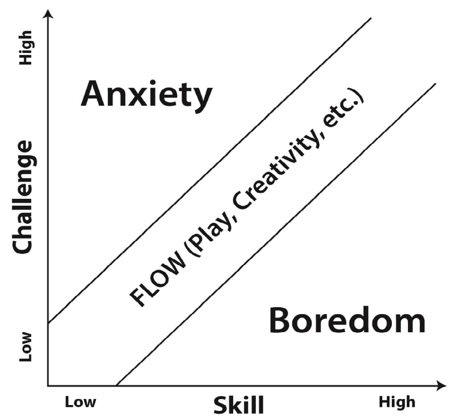
The self-determination theory Ryan and Deci (2017) defines a spectrum of motivation anchored around the concepts 'amotivation', 'intrinsic' and 'extrinsic' motivation. Amotivation is defined as the lack of intentionality or motivation towards any given potential action such as the performance of motor exercises. External motivation, provided by external influences from the individual (e.g., rewards, promotion, absence of punishment) may offer a powerful source of motivation but are not maintainable over extended periods of time. Internal motivation on the other hand, stems from the individuals themselves and can act as a more durable source of behavioural change. The fundamental source of this type of motivation is defined by the theory as the degree to which three basic psychological needs (autonomy, competence, and relatedness) are fulfilled. The better this fulfilment, the higher the internalisation, identification, and motivation of the individual, which may then result in changes to health-related behaviour and better therapeutic outcomes.

2.2 Video games and motivation

Games offer the player a virtual environment in which they can actively participate (opposed to passive forms of entertainment such as movies and television). Since games are often specifically designed to engage and entertain their players, these closed systems can act as ideal laboratories for research on (intrinsic) motivation and engagement (Elson et al., 2014). The features of a video game can range from simple to complex, solitary to social and competitive to cooperative, or anything in between. These features can support or hinder the fulfilment of the basic psychological needs highlighted in the SDT and thus affect the players as much as 'real world' interactions (Ryan and Deci, 2017).

Another important factor in the engagement and intrinsic motivation of a player is the concept of 'flow'. Flow is defined as a mental state of intense and focused concentration in which action and awareness are fully merged (Csikszentmihalyi, 2014). A person who is 'in the flow' operates at full capacity (Deci, 1975) and often perceives the activity as intrinsically rewarding, meaning that the end goal often is just an excuse for the process. Entering the flow state depends on the dynamic equilibrium between the perceived challenge of an activity on the one hand, and the individual's perceived competence within the activity on the other. The concept of flow is best illustrated by the chart in Figure 1, showing the 'Flow channel' between anxiety and boredom related to the perceived skill and challenge (Csikszentmihalyi, 2014). Due to the intrinsically motivating characteristics of flow, this concept often plays an important role within game design.

Figure 1 Visual representation of flow theory



3 Technology-assisted rehabilitation

Previous research in rehabilitation has shown that motivation of patients has an influence on their rehabilitation outcome, hence it becomes a crucial factor in the determination of rehabilitation success and effectiveness. Integrating technology into rehabilitation has been considered to play a helpful role in improving patient motivation. Over the last decades, research on interactive systems to support rehabilitation has gained a lot of attention, especially with regards to the potential of increasing patient motivation during rehabilitation.

Most research investigating technology-assisted rehabilitation through the development of supporting interactive systems has suggested that such systems are more motivating for patients compared to traditional rehabilitation. A number of such interactive systems has been developed to support a range of rehabilitation such as serious games designed to support balance rehabilitation therapy of cerebral palsy patients (Jaume-i-Capo et al., 2014), virtual reality-based systems for rehabilitation of stroke (Eng et al., 2007), Parkinson's (Yu et al., 2011) and cerebral palsy (Weiss et al., 2014), augmented reality for rehabilitation of children with intellectual disability (Richard et al., 2007), interactive collaborative environments for disabled children (Marti et al., 2007), and also tangible interfaces developed to support post-stroke rehabilitation therapy (Hilton et al., 2002) and cognitive rehabilitation for Alzheimer patients (de la Guia et al., 2013).

3.1 Tangible user interface for rehabilitation

Following the rise of research on technology-assisted rehabilitation, research interest in the area of TUIs designed specially to support rehabilitation have also seen an increase. A TUI is an interface which links the digital to the physical world. TUI allows users to interact with digital information through the manipulation of common physical objects and/or architectural surfaces (Ishii and Ullmer, 1997). This is done by physically representing digital aspects and giving the user the ability to physically interact with them in a way people interact with the physical world (Shaer and Hornecker, 2010; Behrenshausen, 2007).

In the context of rehabilitation, TUI has a lot of potential due to its nature. There have been a number of rehabilitation systems developed based on TUI approach since it is considered to be more intuitive and accessible for patients with a low level of technology experience. For example, a TUI built to be used for written and spoken comprehension therapy in aphasic patients (Rybarczyk and Fonseca, 2011), tabletops used in neural rehabilitation (Leitner et al., 2007) and motor rehabilitation (Annett et al., 2009), and a pervasive training system providing tangible interactions in physical rehabilitation for the upper limbs (Vandermaesen et al., 2014). In these studies, TUI was mainly chosen as the technology to support rehabilitation because of the advantage of the manipulation of physical objects that is considered to ensure an effective transfer of therapy exercises into everyday life activities.

One of the key concepts of TUI is interactive surfaces, in which we transform each surface within architectural space (e.g., walls, desktops, ceilings, doors, windows) into an active interface between the physical and virtual worlds (Ishii and Ullmer, 1997). Interactive surfaces have become popular in the area of rehabilitation as it supports natural and direct interaction which provides an important advantage for patients. There has been a growing interest in the use of interactive floors for rehabilitation purposes such as stimulating physical activity of psychogeriatric nursing home residents (Braun et al., 2015) and rehabilitating persons with balance problems due to stroke or other disorders (Betker et al, 2005; Caltenco et al., 2017). These studies have shown that interactive surface technology, used on the floor, is a promising tool for physical and postural control rehabilitation. To date, no research has been conducted to develop interactive surfaces (i.e., floors) to assist balance rehabilitation for children with DCD.

3.2 Exergames for rehabilitation

Exergaming has shown to be promising in the field of technology-assisted rehabilitation. There has been a wide range of research in rehabilitation using commercially available (business to customer) gaming technologies such as Nintendo Wii, Nintendo Wii-Fit, Sony Playstation II Eye Toy, Sony Playstation 3 Move, Microsoft Xbox 360 Kinect and Dance Revolution (Bonnechère, 2018). Even though these tools were initially developed to support commercial gaming for a very broad target group, therapists quickly became aware of their potential.

Various studies were conducted to assess the possible benefits these exergames might offer therapists and their patients. Overall, research has shown that clinical interventions with commercial videogames resulted in comparable outcomes to conventional interventions within various pathologies (Bonnechère et al., 2016, Mat Rosly et al., 2017). In general, exergaming interventions have shown initial positive results in the rehabilitation of among others, adults with Parkinson's Disease, obesity, stroke, general balance deficits, older adults and children with Cerebral Palsy and DCD (Bonnechère et al., 2018). Patients with Parkinson's Disease who adhered to a Wii-based intervention showed comparable improved performances in activities of daily living to subjects who underwent a conventional therapeutic intervention (Pompeu et al, 2012). In patients suffering from obesity, exergames can increase physical activity levels due to the increased enjoyment and engagement during training (Höchsmann et al, 2016). Within this population they have even shown long term benefits by improving the health-related behaviour of the obese individuals (Johnston et al, 2012). In stroke, exergaming interventions showed increased repetitions of exercises (Peters et al, 2013) and improved balance outcomes during both the acute (Rajaratnam et al. 2013) and chronic stages (Hung et al, 2014; Cho et al, 2012).

The use of exergames with older adults has shown improved balance and general motor performances (Donath et al., 2016, Maillot et al, 2014), a reduced risk of falls (Cho et al, 2014) and improvements in both motivation (Nacke et al, 2009) and cognitive skills (Toril et al, 2014). Research on exergaming for children with DCD – which mainly focused on increasing balance and improving motor skills – has found that exergames have resulted in positive medical results and were also perceived as enjoyable by the children (Gonsalves et al., 2015; Smits-Engelsman et al., 2017).

All of these studies suggest that exergaming in rehabilitation is more engaging, enjoyable and offers comparable or better therapeutic outcomes than the more traditional and analog approach to therapy exercises, and this despite the fact that none of these games were designed for clinical purposes. Exergames that are specifically designed towards certain clinical requirements may lead to even better therapeutic outcomes (Bonnechère et al., 2016). As a result, the number of interactive systems specifically developed for medical rehabilitation has increased over the last few years. These tools were made with the specific goal of helping a specific target group with predefined medical conditions. Some examples include Silverfit (Rademaker et al, 2009), Vivid GX (Rand et al., 2004), Tovertafel (Augstein et al., 2014) and fun.tast.tisch (Augstein et al., 2013).

4 Evaluation of enjoyment in TUI exergames

Previous research has shown that enjoyment in rehabilitation exercises helps in engaging patients during training and maintaining patient motivation throughout rehabilitation (Burke et al., 2009; Järvikoski et al., 2013). Enjoyment has been considered as a measure to evaluate TUI and exergames since both have shown to convey enjoyment to the users during interaction (Limperos and Schmierbach, 2016; Xie et al., 2008).

Previous evaluations of TUI have often incorporated user enjoyment as one of the measures used. The study of evaluating the learning process of archaeological artefacts with TUI involved the measurement of time on task, perceived task load, learning outcomes, spatial presence and enjoyment (Pollalis et al., 2018). Another study is the evaluation of tangible game controller interfaces which covered measuring flow, perceived naturalness of control action mapping, player experience of need satisfaction, mental effort, performance and enjoyment/satisfaction (Reinhardt and Hurtienne, 2018). In both studies, the enjoyment was measured by asking the participants in the evaluation to rate their level of enjoyment using the interface on a Likert scale.

In most research, exergames used for rehabilitation purposes are evaluated on two main aspects: the medical results and the enjoyment experienced by the patients. Quantifying the medical results during the course of the rehabilitation process is relatively easy and can be achieved by the use of outcome measures. Quantifying the enjoyment of a patiënt has proven to be much more difficult. Especially in the field of pediatric physiotherapy there appears to be no general consensus regarding the terminology and assessment of enjoyment and motivation in children (Meyns et al., 2018). Previous research within this field for example has seen use of the smiley face Likert scale (Mironcika et al., 2018) and relative enjoyment scale (RES) (Núñez Castellar et al., 2015) to assess the enjoyment of a game. The RES was specifically developed using the SDT-principles as a framework and thus provides a more general and reliable self-report experience measure (Meyns et al., 2018; Van Looy et al., 2018).

For evaluating TUI and exergames with children, we consider employing the relative enjoyment scale for children (RES-C) to quantify enjoyment. Compared to other scales with Likert-type items, the RES-C scores have the advantage of providing normally distributed scores and it is less sensitive to the effects of social desirability (Núñez Castellar et al., 2015). It is also suitable for children since children are requested to compare the enjoyment of doing a target activity with another activity that is familiar to them in their daily lives (e.g., cycling, watching television, going for a walk).

5 Matti training platform: user evaluation

Figure 2 depicts Matti, an interactive gaming mat developed as a training platform to support physical rehabilitation for children with DCD. The complete system consists of an interactive pressure sensitive surface with an integrated LED-grid, a TV/desktop screen, and a laptop or desktop computer, which runs the creative therapy software (creative therapy platform) for Matti. The required software to control the interactive surface can be either installed as an offline application or used online through a browser-based version. Both versions of the platform allow therapists to setup and adjust the various exergames, but only the online version allows for the creation of user profiles and long-term storage of game scores and results.

We have implemented the Matti device in a clinical setting as shown in Figure 3. All exergames included in the Creative Therapy function in a similar way. The player is offered a specific game state through either an external screen (laptop or monitor) and/or the LED-grid integrated within the device. Visuals on the external screen mainly consist of full colour animations rendered in a game-engine, while the visuals on the LED-grid are more abstract and often use simple shapes (circles, square, arrows) with various, yet specifically chosen colours, which often relate to coloured elements on the external screen. Almost all games require the patient to interact with the games by touching the area highlighted by the visible LED integrated within the device. Depending on the position of the lit-up interactive regions on Matti, the position of the patient on or next to the device and the nature of the exergame (reaction-based game, games requiring coordination, prolonged pressure, etc.) the therapists is able to provoke specific movement patterns in their patients. By adjusting numerous parameters within the exergames themselves (e.g., duration of game, size of lit-up shapes, level of randomisation, active area on the device, etc.) therapists can easily tailor the games to the individual needs of the patient.

Figure 2 Overview of the Matti system

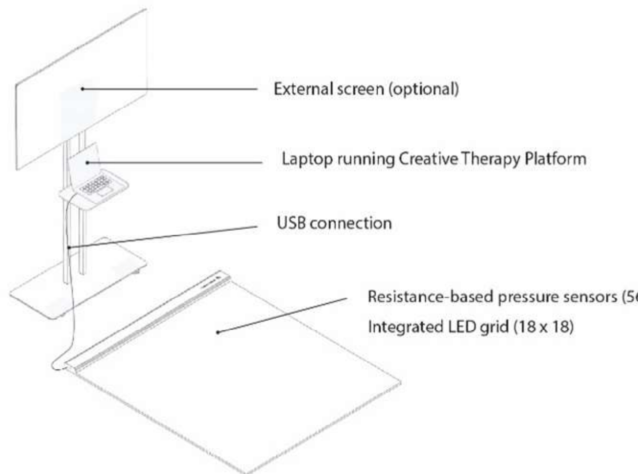
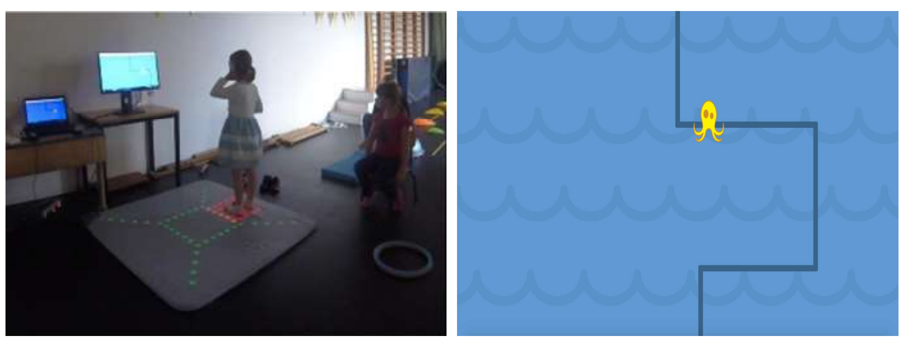


Figure 3 Matti training platform, (a) interactive surface/mat (left) and (b) therapy exercise (right) (see online version for colours)



(a) (b)

In the example shown in Figure 3, the aim is to navigate the little octopus along the dark track. The LEDs embedded in Matti's surface depict four clear zones, which coincide with the four cardinal directions (forward (N), backward (S), right (E) and left (W)). With the octopus moving at a constant speed in the direction dictated by the player's position, the patient is required to stand in the correct zone at the correct moment, in order for them to complete the enys track. Through stimulating visuals and gamification elements (e.g., progression bars, high score tables, etc.) within the Creative Therapy platform the aim is to motivate patients to complete and repeat their therapeutic exercises while enjoying challenging exergames.

5.1 User Study 1: Children with DCD

To evaluate Matti as an engaging TUI for rehabilitation patients, a user study was conducted involving children with DCD. The main goal of this user study was to get a better idea of how to improve the system in the next stage of the prototype design. The insights gained from the user group and relevant stakeholders (e.g., physiotherapists and (grand)parents of children with DCD) can be considered in further development cycles.

The user evaluation was carried out at a specialised physical rehabilitation centre for children with DCD. A total of 17 children (aged between 5 and 11) diagnosed with DCD were involved as participants in this user evaluation. The user evaluation consisted of two physical therapy sessions for two weeks:

1 therapy with parkour exercise

2 therapy with Matti exercise.

In the first week, the participants were asked to follow a parkour exercise involving different motor tasks, as shown in Figure 4(a). Physiotherapists commonly use this exercise as part of a therapeutic intervention for children with DCD since it can be easily altered, which helps maintain the children's interest over time. It is mainly used to train and stimulate the patients' motor skills by combining multiple obstacles, such as crossing a balance beam, jumping over obstacles, throwing and catching a ball, and climbing a frame. During the second week, the participants were asked to perform various exercises on Matti. The setup and performance of the DCD children during this session are illustrated in Figure 4(b). Both the first (parkour exercise) and second session (Matti) lasted 30 minutes.

We employed the RES-C to quantify the enjoyment of the DCD children during their therapy sessions. After each session, the participants would rate their experienced enjoyment during the session by comparing it to the following six activities: cycling, watching television, eating, cleaning up a table, taking a walk, and grocery shopping. We also interviewed the participants to get their general opinion on Matti, focusing on functionality (both hardware and software), the game, and their suggested alterations. Additionally, we interviewed the participants' parents or grandparents to gain insight into whether they saw any added value that Matti might bring to the therapy of their child or grandchild. This question was extended to include both therapies at the rehabilitation centre or home (telerehabilitation). The third series of interviews were carried out with the physiotherapists and focused on the applicability of Matti in the context of physical therapy for DCD children. We asked their views on the necessary changes Matti required so they could use it (even better) in their therapy sessions.

Based on the RES-C scores gathered from the participants, we calculated the average scores for both conditions (conventional intervention and Matti). The average RES-C score for the therapy with an obstacle parkour was 4.38, while the RES-C score for the therapy session with Matti averaged 4.91. A paired sample t-test showed no significant difference in the RES scores between the two therapy conditions ($p = 0.129$). This indicates that the DCD children perceived similar levels of enjoyment between both therapy exercises using parkour and Matti, which stipulates that performing therapy exercises with Matti was as enjoyable for them as the conventional exercises with obstacle parkour. The children rated relatively high levels of enjoyment (above 4 out of 6) in both conditions, with a slightly higher level of enjoyment for Matti.

Figure 4 User evaluation session with DCD children, (a) Parkour exercise and (b) Matti exercise (see online version for colours)

(a) (b)

Furthermore, the interview results showed that all participants liked playing the game as part of the therapy exercises on Matti. Thirteen participants said they liked to play the game because the interactive lights on the mat lit up when they stood on them. All participants were observed to be able to play the game when it was set to easy mode. However, when the physiotherapists challenged the participants with more difficult modes, seven participants perceived the game to be less appealing because it became too difficult or challenging for them. When asked to state their preference between Matti and the obstacle parkour exercise, 9 participants preferred the former, 6 preferred the latter, and 2 had no preference as they liked both equally.

From the interviews with 14 guardians of the participants (their parents or grandparents), we learned that 11 people saw an added value in the use of Matti to support the therapy of their (grand) children who have DCD, 1 person did not see any added value, and 2 had no opinions. Exercising balance, spatial awareness, and coordination were the foreseen added values. Ten of them were also willing to use Matti at home by renting or borrowing it. The main concern was the limited number of games, where 4 guardians agreed that more games were needed to keep the exercises exciting for the children.

The interviews with the physiotherapists showed that they did perceive the Matti as a potentially viable part of their therapy for DCD children. Three main concerns about Matti were expressed: accuracy and reaction time of the hardware, customisation of the games to the needs of the patients, and the number of games offered to keep the patients motivated. The hardware did not react fast enough, which can be very frustrating for the patients and was also the biggest concern of the physiotherapists. In Matti, the sensitive matrix of the mat was vastly reduced to only four spatial zones: middle, back, left, and right. This was seen as a limitation to the number of movements the patient could do during the exercises. The physiotherapists wanted the games to use the full pressure-sensitive matrix. Additionally, they also would like to have the possibility to adapt the game according to the needs of the patient. Lastly, they wanted more varied yet exciting games which cover important gamification aspects such as challenge, level of immersion, rewarding systems, level systems, and adaptable games. These suggestions gave us a clear idea of what needs to be considered and which next steps need to be undertaken in developing the next version of Matti.

5.2 User Study 2: older adults with mobility issues

To assess the applicability of the device in the context of geriatric physiotherapy, a second short explorative user evaluation was performed at a Belgian senior care centre. Therapists were given complete freedom to implement the device and software according to their expert judgement and the senior's individual capabilities and needs. After some preparatory sessions, 7 older adults were recruited to a communal therapy session using the Matti device as shown in Figure 5. Inquiries with regard to the design and interaction with the device and the lay-out, legibility and ease of use of the digital interface were gathered through semi-structured interviews with both patients and therapists.

Figure 5 User evaluation session with older adults (see online version for colours)

Analysis of the interviews showed that 4 out of the 7 participants enjoyed their experiences on Matti, while the other participants stated that they found the device not enjoyable. The main reason for their disapproval was the perceived difficulty level of the exercise and sporadic unresponsiveness of the device. The following group interview with the clinicians also pointed out these high levels of perceived difficulty. Furthermore, therapists remarked that due to the foam surface there might be some additional risk of falling, especially in an older population. They also remarked that the use of visual cues on both an interactive device on the floor and an external screen might be too difficult for a senior population. Overall, this version of the Matti device was deemed feasible, but a little too demanding for a geriatric context. However, both patients and therapists showed interest in the development of these types of devices.

6 Discussion and conclusions

The user studies in this paper illustrated how different populations need different requirements. While playing similar exergames on Matti, the older adults reportedly experienced more difficulty with these exercises than the DCD children did. The user studies also showed no significant increase of motivation levels in DCD children when comparing RES-C scores to those of a conventional intervention. The small sample size, single-session testing protocol and use of the earlier version of the Matti system might all contribute to this result.

This paper concludes that the Matti training platform has shown great potential as an interactive system to increase patient engagement in a clinical environment, specifically in the context of physical rehabilitation for people with balance and coordination issues such as older adults and children with DCD. However, future research on the overall impact of the Matti on both the short- and long-term motivation of various clinical populations and age groups is still required.

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