A Digital, Game-based Application to Support Treatment of Parkinson's Disease: A Design Thinking Approach

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Abstract: One of the most common neurodegenerative disorders that affects more and more people at an advanced age is Parkinson's disease. Patients suffer from various symptoms and especially the motor restrictions and psychological symptoms worsen the quality of life of the affected persons. The physical therapy for this disease to improve motor performance and complementary exercises is characterised by repetitive training and patients often suffer from a strong exhaustion and lack of motivation due to their disease. To address these problems, a serious game concept for Parkinson's therapy was developed. The concept was created using the *Design Thinking* methodology for a user-centred design. The final result is the concept and prototype of a competitive multiplayer exergame that was developed to increase the motivation of the patients to participate through social play and the idea of competition in order to support the motor therapy of Parkinson's disease patients.

1 INTRODUCTION

Parkinson's disease is a neurodegenerative disorder that affects 2-3% of the population over 65 years (Poewe et al., 2017). The most associated symptoms are the four cardinal signs concerning the motor system: rest tremor, muscle rigidity, postural instability and bradykinesia (Balestrino & Schapira, 2020). Rest tremor is manifested by alternating involuntary movements of the hands, feet and sometimes other body parts when the patient is at rest (Helmich et al., 2012). Muscle rigidity refers to the continuous and constant increase in muscle tone with resistance to passive movements regardless of movement speed and direction of movement (Delwaide, 2001). Disturbed postural reflexes and reduced control over one's own movement often cause balance difficulties in Parkinson's patients, leading to postural instability (Bloem, 1992). Bradykinesia, the slowness of movement, often occurs in connection with hypokinesia, the deceasing of movement. The movements of the patients are often under-scaled due to wrong motion perception (Balestrino & Shapira, 2020). Through external cueing and big flowing exercises as compensatory movement strategies, this symptom can be alleviated (Janssen et al., 2014).

Non-motor symptoms in Parkinson's disease range from autonomic dysfunctions to sensory disorders and various psychiatric disorders. Self-reports of patients show that especially nonmotor symptoms like depression and fatigue affect their perceived quality of life (Barone et al., 2009). Fatigue is characterized by an intense feeling of tiredness, exhaustion and listlessness and concerns more than half of the patients with Parkinson's (Krupp & Pollina, 1996). Fatigue is additionally associated with lack of motivation, pain, lower quality of life, poorer perception of psychological well-being, more severe depressive symptoms, and an increased prevalence of sleep disturbances (Hagell & Brundin, 2009; Stocchi et al., 2014). Friedman and colleagues advise physical exercises and group motivational training to counteract fatigue (Friedman et al., 2007).

A *serious game* is an interactive computer-based game software that has been developed with the

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intention to be more than entertainment. It is used to impart skills or knowledge embedded in a motivational and entertaining context (Ritterfeld et al., 2009). Serious games are used in various fields from healthcare, marketing, social change, education, military, occupation, well-being, advertising, cultural heritage, interpersonal communication and academic purpose (Laamarti et al., 2014; Ritterfeld et al., 2009). A huge number of serious games in healthcare can be classified as so-called *exergames*, often used for motor rehabilitation. Exergames combine a playful approach (*game*) with physical activity (*exercise*) (Malaka et al., 2016). Instead of classic input devices such as keyboard and mouse or controller, physiological feedback from the player is used to interact with game (Malaka et al., 2014).

Due to the repetitive nature of Parkinson's therapy patients get physically tired and mentally bored during classic therapy training resulting in lack of motivation (Assad et al., 2011). Serious exergames offer themselves as a therapy supplement for Parkinson's therapy due to their playful motivation to move in combination with therapeutic effects (Rego et al., 2014). Aim of this paper is an appropriate exergame-concept developed for Parkinson's disease patients with mild to moderate Parkinson's disease to improve hypokinesia and fatigue.

2 METHODS

To develop a suitable serious game concept for Parkinson's therapy the *design thinking* methodology is used which was developed to systematise creative processes and to find user-centred solutions to problems (Brown, 2008). Depending on the selected model, the design thinking process is divided into five or six phases that are iterated through. Within this work we have chosen the model presented in the work of Wölbling and colleagues (Wölbling et al., 2012), consisting of *understand, observe, point of view, ideate, prototype* and *test*.

2.1 Literature Review

In the *understand*-phase the initial definition of the problem and a broad outline of the subject matter are required. The topic, main stakeholders and the context are identified. First results can be obtained through literature research, as in this case. Often there are unanswered questions that can be answered in the next step (Wölbling et al., 2012).

To gain more insight, related work was investigated. Applications were considered that can be classified as serious games and that define patients with Parkinson's disease as the target group. The applications were identified through literature searches on the online databases *ACM Digital Library, APA PsycNet, PubMed, ScienceDirect, IEEE Xplore Digital Library, ResearchGate, Semantic Scholar* and *Springer Link*. Applications were excluded that used gamification aspects but were not implemented as a serious game, serious games that did not aim at motor improvement, or applications that were not explicitly conceptualised and implemented for Parkinson's patients. The following keywords were used in the search: "exergame", "active video game", "serious game", "exercise", "exercise therapy", "digital rehabilitation", "digital therapy support", "parkinson's disease", "parkinson".

2.2 Expert Interviews

The objective of the *observe*-phase is to understand and empathize with the user to create a suitable product for the target group. In most cases, qualitative interviews or quantitative surveys are conducted. The results are used to understand needs and obstacles and answer open questions after the first phase (Wölbling et al., 2012).

For the *observe*-phase expert interviews with physiotherapists were hold. Expert interviews are used to gain expert knowledge through a qualitative survey (Meuser & Nagel, 2009). The decision was made not to conduct the interviews with representatives of the target group themselves, as they might have difficulties in formulating general requirements due to the very individual characteristics of the disease. The expert interviews with three physiotherapists were conducted to identify requirements for a digital game-based therapy support. The interviews were intended to clarify open questions and substantiate the concept with practical experience values. Each interview lasted half an hour and they were held between the 23.02.32021 and the 26.02.2021 due to the pandemic situation via the video conferencing tool *Teams*. For later content analysis, the interviews were recorded and later transcribed with consent of the participants. Questions asked during the semi-structured interview concerned

1. methods of motor therapy for Parkinson patients that are suitable for a digital approach,
2. strategies for dealing with lack of motivation during therapy,
3. requirements of the target group for game perception and design,

4. potentials and obstacles caused by the game mechanics and interaction and
5. idea generation and wishes for an optimal game design.

The analysis of the interviews follows the data analysis of expert interviews according to Meuser and Nagel (2009) in order to obtain interpretable results. The data analysis according to Meuser and Nagel is divided into transcription of the recorded interview, paraphrasing the text according to thematic units, ordering the paraphrased passages thematically, category formation and comparison of the statements and finally theoretical generalization through arranging the categories according to their internal relations.

2.3 Concept

During the *point of view*-phase the generated information from the previous phases should be clustered and provide answers to the questions: What problem must be solved? For whom this problem must be solved? In the *ideate*-phase ideas to solve this problem are generated. With the help of the knowledge base, that has been accumulated, a user-centred solution can be found. For the *prototype*-phase a concrete example implementation of the final idea is created. The prototype gives the opportunity to experience a tangible and assessable version of the idea (Wölbling et al., 2012).

The result of the *point of view*-phase is used as a reference point to develop a concrete concept idea. This concept idea is implemented as a prototype using the game engine Unity 3D in version 2020.3.1f1 in the programming language C#.

2.4 Evaluation

The finished prototype is presented to potential users during the *test*-phase to give feedback on the idea and determine the usability of the solution. With the help of the results, the solution approach can be iteratively revised (Wölbling et al., 2012).

The prototype was evaluated through qualitative interviews with experts. Six participants took part, three of whom worked as software developers for serious games (S1, S2, S3) and three as physiotherapists (P1, P2, P3). Two of the physiotherapists already had experience with serious game applications in therapy (P1, P3). Due to the ongoing pandemic situation, the interviews were conducted via *Teams*. The subjects were not able to use the application themselves because of the current situation but they were shown screenshots of the menus and interface and videos of various game scenes (introduction, calibration, game, game end) of the prototype with exemplary use. The participants were then asked about the suitability of the application for the therapy and the target group and about the usability and development of the prototype. The interviews were held between the 24.05.2021 and the 30.05.2021 and each interview lasted 45 minutes. The interviews were recorded, transcribed and analysed according to Meuser and Nagel (2009).

3 RESULTS

The results of the different *design thinking*-phases are shown below. The most important findings of the literature review, the results of the expert interviews, the final concept resulting from these findings and the results of the evaluation are presented.

3.1 Literature Review

The search for related work resulted in 13 serious games for therapy support in Parkinson's patients (Assad et al., 2011; Dauvergne al., 2018; Dias et al., 2017; Galna et al., 2014; Garcia-Agundez et al., 2017; Hermann et al., 2013; Nuic et al., 2018; Pachoulakis & Papadopoulos, 2016; Pachoulakis et al., 2018; Palacios-Navarro et al., 2015; Paraskevopoulos et al., 2014; Sanchez- Herrera- Baeza et al., 2020; Van der Meulen et al., 2016).

Of the applications considered, almost all can be classified as exergames for improvement of motor skills. Only the game by Dauvergne et al. (2018) trains the sense of rhythm. Evaluations of the applications show that they are capable of improving the skills of the patients.

Most used input device for the applications were different kinect bodytracking solutions (*Xbox 360 Kinect, Kinect for Windows, Kinect for Xbox One, Kinect 2 for Windows, Azure Kinect*). Especially due to the use without additional input devices or optical markers, they are well suited for the target group.

Except for the collaborative serious game *Window-Washer* (Hermann et al., 2013), all games are implemented as single-player applications. There is potential here that has not yet been exploited by the existing range of applications.

3.2 Expert Interviews

The most important statements on the various subtopics of the expert interview are presented below.

3.2.1 Suitable Exercises

The participants reported that the motor therapy for Parkinson's disease patients is very diverse, and patients are treated differently depending on their main symptoms (P1, P2, P3). The exercises range from gait training, stretching exercises to muscle building but main target for every physiotherapist is to maintain the capability to perform everyday movements. Gait training (P2, P3), classic exercises like squats (P2, P3) and the LSVT BIG program (P1, P3) named the participants as suitable for a digital game-based application.

3.2.2 Strategies to Increase Motivation

Day-dependent fatigue and depression were named as a huge hindrance of therapy. In connection with this, a lack of motivation often occurs (P1, P2, P3). Sometimes patients even perform aggressive behaviour (P3). Shame for symptoms is common but decreases with increasing trust in the therapist (P1, P3). The interview partners described that if a patient is disinterested, lacking motivation, or exhausted they often use pauses or rest periods (P1, P2, P3), but the main goal is getting the patient back to the therapy program (P3). In difficult cases, one participant reported implementing an alternative stretching program with patients (P1).

3.2.3 Requirements of the Target Group

In order to support patients in the use of technology and to avoid safety risks, the participants agreed that a therapist as a controlling authority should support the patients in using the application and that a home application would not be useful (P1, P2, P3).

According to the participants, it would be important for the target group to be able to adjust the difficulty of the game, because the patients should neither be over-challenged nor under-challenged (P1, P3). In particular, since the severity of Parkinson's disease can vary greatly, digital therapy support should offer a certain degree of variability (P3). For example, the possibility to interact with the game while standing or sitting was suggested (P1, P2, P3).

Particularly with regard to hypokinesia, three-dimensional visualisation of the patient's body movements would be useful to provide them with external cues to recalibrate their body sensation and thus help them adjust their movement size (P2).

The theme of the digital game application should be chosen with care to appeal to the target group (P1, P2, P3). Topics such as sports, dancing, music or outdoor activities are interesting for most representatives of Parkinson's patients, who are mostly of older age (P3).

The possibility to take breaks is absolutely necessary in a digital playful therapy supplement because the patients tire quickly (P1, P2, P3). The breaks should be determined by the accompanying therapist or by the patient himself and not be dictated by the game system (P2).

Due to the advanced age of the patients, instructions on the correct execution of the exercise and the use of the system should not be complex and be given several times during the game (P1, P2).

3.2.4 Obstacles

The design as a competitive game could be problematic if there is a large difference in performance between the players (P3), if the players are in poor daily form (P3) or if the players have set themselves an unrealistic objective (P1, P3) and thus rather reduce motivation instead of promoting it. Another danger of the competitive situation could be that the players overreach themselves if they are too ambitious (P1). However, the pressure to perform or the stress can be reduced by a well thought-out game design. Possibilities here would be to set realistic and individual goals (P1), to offer the prospect of partial goals (P1), to offer incentives not to overdo oneself (P1), to create a non-judgemental and exercise-related environment (P3) and to direct the focus of the application on the therapy purpose and not on competition (P2).

Due to the age of the patients, initial scepticism and reluctance towards the new form of interaction is likely but should reduce over time (P2, P3). The motor control could offer the players opportunities to not execute the movements cleanly but still achieve high scores (P1, P3). This should be addressed through an appropriate exercise selection and good movement instruction (P3). Interaction movements should be designed with the patient's motor symptoms in mind. In particular, tremor and the cogwheel phenomenon could hinder interaction if they are not taken into account (P2).

3.2.5 Potentials

All participants agreed that playful therapy methods are a high motivational incentive for the patients. They offer additional incentives and variety to the therapy and expand it through gamification (P1, P3).

A competitive game design offers above all a comparison of performance (both with one's own performance and with that of the opponent) which can generate strong motivation in the patients (P1, P2,

P3). The social interaction that arises from a competitive situation is a useful and motivating complement to individual therapy that is also used in group therapy (P1, P2, P3), which often incorporates social interaction with a therapeutic purpose into a playful setting (P1).

The motor game control through optical body tracking as a new and interesting concept is a great motivating factor that can encourage patients to use the application (P3). The fact that no additional aids are required makes it very easy to start using the system (P1). Motor control through body tracking technology can enable the possibility of linking different training approaches (P1). Since the patients themselves are responsible for the control, they can determine the pace and the extent of movement themselves (P1), which is not always the case with other technical therapy supports. The visualisation of body movement made possible by optical body tracking can sensitise the patients' body perception and support them in recalibrating their movement size perception (P2).

3.2.6 Idea Generation

To optimally complement conventional therapy, the participants wanted above all varied settings as a playful digital supplement and ideally variable offers for different patient interests (P1, P3). Interesting topics mentioned were realistic scenarios from everyday life (P1), sports to create a natural competitive situation (P2) and the use of music and rhythm (P2, P3).

3.3 Concept

The aim of this work is to develop a serious game that supports and complements Parkinson's therapy. The target group of the application are people with mild to moderate Parkinson's disease (Hoehn and Yahr-scale stage I to III) (Hoehn & Yahr, 1967). In these stages of disease, motor impairments of the patients are present but the patients are able to manage his or her daily life independently and the ability to stand and walk is still given. Cognitive impairments of memory and behaviour are not yet pronounced. The planned application is intended to improve the hypokinesia of the patients by integrating suitable therapy contents and visualising the body movements of the players on the one hand, and to counteract the fatigue symptom through a motivating and social game design on the other hand.

3.3.1 Genre

The conceptualised game *PARKinson* can be classified as a casual game. Casual games are characterised by easy interaction, quick-to-learn gameplay, fast achievements and the possibility of short play sessions. They offer frequent rewards and a benevolent play rating (Kuittinen et al., 2007). Since casual games often have a low level of complexity, they are particularly suitable for an older target group in order to avoid cognitive overload (Gerling et al., 2011). Playing casual games is additionally able to reduce depressive symptoms of the players (Russoniello et al., 2009).

The theme of the game is chosen according to the preferences of the target group (McNaney et al., 2015; Othlinghaus et al., 2011). A gardening theme was chosen, which is also an activity associated with relaxation and stress reduction (Scott et al., 2015).

3.3.2 Game Idea

The interaction movements are based on the basic idea of the *LSVT BIG* training to improve the hypokinesia of the patients with extensive and flowing movements. The *LSVT (Lee Silverman Voice Treatment)* Program is a therapy concept that targets on increasing the amplitude of the speech motor system (*LSVT LOUD*) or the limb motor system (*LSVT BIG*). *LSVT BIG* aims to enlarge motions by recalibrating the patient's perception of his own movement and thus improve the hypokinesia of the patients. The program contains different exercises, which encourages the patient to make great movements (Fox et al., 2012). *LSVT BIG* was also considered suitable by the interview partners to be transferred into a digital therapy application. In the game the players have to move within their entire kinesphere (the space around the body that can be reached by stretching and extending limbs) (Laban & Ullmann, 1971) in order to interact with the game. The players select objects scattered across the game screen with their hand. Players' body movements are captured using the *Azure Kinect*. The *Azure Kinect* is a camera system consisting of a depth camera and an RGB camera. The body tracking-feature of the *Azure Kinect* is able to detect human bodies and connects them with a skeletal representation containing 32 joints. This technology allows tracking the patients' movements and embedding them into a playful context.

Unlike most commercial exergames, the movements in the game only serve as a means of interaction and not as a basis for evaluation of the game success. Because the assessment of movement

in exergames was reported as not suitable for Parkinson's patients (McNaney et al., 2015). The success of the game is therefore not dependent on motor performance, which is influenced by the disease, but on abilities that are not influenced by the disease in mild to moderate Parkinson's disease (Poewe et al., 2017). For a successful game, players need to use their visual-spatial working memory (Schumann-Hengsteler, 1996).

The game principle is derived from the classic *Matching Pairs*-game (also known as *Concentration* or *Pairs*) In *Matching Pairs*, the players' task is to find matching pairs of cards from a series of cards that lie face down in front of the players. Players take turns turning over two cards and the game ends when all cards have been successfully turned over. The player who has matched the most pairs wins (Zwick & Paterson, 1993). The well-known game concept of *Matching Pairs* facilitates the target group's entry into the unfamiliar field of digital therapy support (McNaney et al., 2015; Nap et al., 2009).

Matching Pairs is a competitive multiplayer game. Both in the interviews and in the literature, the motivational potential of social play is emphasised (Ryan et al., 2006). Competitive play in particular has positive effects in terms of motivation and fun (Peng & Crouse, 2013; Göbel et al., 2010). In this game the players are highly interdependent because they have access to the same resources or cards and the actions of the opponent influence their own actions. During the game there is negative and positive interdependence between the players: players take resources from each other, but the actions of the opponent can also give players important clues about card positions for their own actions. High interdependence forms and strengthens social ties (regardless of whether it is positive or negative) (Depping et al., 2018). Social connection is in turn associated with motivation according to the self-determination theory (Ryan & Deci, 2000). In addition, in *Matching Pairs* it is not possible to make mistakes: either you reveal a pair of cards, or you expand your knowledge of the card positions during a move.

The rules of the traditional *Matching Pairs* game are slightly modified in the conceptualized digital application. Unlike *Matching Pairs*, there is no provision for a player to have another turn at a found pair to avoid long periods of inactivity and not to further emphasis a possible cognitive imbalance of the players.

Players interact with the game through the position of their selected hand. They move a hand icon across the screen and can use it to select the cards distributed on the screen. To select, they let their hand remain on the respective card for five seconds (which is visually supported by a loading bar around the icon). The motif of the selected card is then revealed. Following the same principle, the player then selects a second card, and its motif is also revealed. If the card motifs are identical, the player receives a point and, for further visual support, the captured cards are marked with flowers in the player's colour. The players take turns to select two cards. The game ends automatically when all pairs of cards have been found but can also be ended manually at any time. In both cases, a closing screen is displayed with the players' scores.

Figure 1: Exemplary play scene of *PARKinson.*

In addition to the free hand selection, it is possible to play the game both sitting and standing. The individualization of the game that was suggested in the interviews is complemented by the fact that the arm span of both players is recorded in a calibration phase and the outermost cards are placed in the individual maximum range of the players in order to create a higher equality of opportunity with different sizes or degrees of mobility. Pauses, that are considered absolutely necessary by the interview partners, are possible at any time during the game because the players themselves take the initiative for actions and do not have to react to actions in the game. If the exhaustion is too great that not all pairs of cards can be found, it is possible to end the game manually at any time and be forwarded to the final scene. The body movements of the players are visualised during the game by using the skeletal representation of the Kinect body tracking. This visualisation was considered useful by the interviewees and in the literature external cues about the magnitude of one's own body movement are advised (e.g. through verbal cues or videos) in order to adjust the patient's body awareness and improve hypokinesia (Berardelli, 2001).

The game should be used as a supplement in the therapy setting and supervised by a therapist (e.g. in group therapy).

3.4 Evaluation

The introduction of the game was considered useful by the interview participants in order to convey the first basic information (goals, rules, characters) (P1, P2, P3, S2). Especially the embedding in a story or in a dialogue with one of the characters was rated positively as this can create an interactive feeling and more engagement (S2).

The playful and narrative embedded testing of the interaction including the calibration of the arm span was rated as entertaining for the patients and good access to the game (P1). The possibility to adapt the game individually to the players through the calibration and the possibility to play both sitting and standing increases the accessibility and makes the game therapeutically useful (P1, P2). It was suggested that the prototype should be supplemented with the ability to recalibrate during the play session (P3). One respondent suggested that it would be useful to explicitly inform the supervising therapist about the possibility of playing while standing or sitting. At the same time, it would be important to make sure that the players are not demotivated when the therapist decides that they are "only" able to play sitting down (P1). Free hand selection is considered very useful as it gives the supervising therapist the freedom to choose which hand to train: The strong or the weak side, both of which can have positive effects: either regarding the training effect or the motivation (P1).

For the main game, the participants suggested even stronger visual and auditory highlighting of game-relevant events and actions for better attention control but also motivating effects (P1, S1, S3). Likewise, they considered different levels for different difficulty degrees and game lengths to be useful. Different items and functions that are unlocked over time would increase the long-term motivation even more (P1, P2, P3, S1, S2, S3).

The gardening theme was rated as appealing to the target group (P1, P2, S1) but one of the participants noted that the subject is probably more attractive for women than for men (P2). The game concept was rated as simple and understandable, but nevertheless creative and appealing (P1). The familiar game concept offered an easy entry for the target group (P1, S1, S2). The controller-less interaction would be intuitive and particularly well suited to the target group (P1). The card positioning and thus the required movements are a good adaptation of the basic idea of LSVT BIG (S2) and would motivate the patients to make therapeutic movements without them happening consciously, as in the case of working through the exercises (P1). Large and targeted movements are trained in this way (P1, S1). The holding times would increase the therapeutic effectiveness (P1). It was also positively emphasised that there is no temporal component that could create stress among the players (P2, P3, S2). The linking of the movements with cognitive training is useful for the target group (P1, S2).

The ending of the game even if it is ended prematurely was emphasised positively, because this would not create the feeling among the players that they would abandon the game (S1).

The participants are of the opinion that the game would be a suitable therapy support. The patients are challenged to use their entire range of motion (P2). The game offers a suitable and meaningful movement interaction for the target group to reach their movement amplitude and can increase motivation and thus achieve the required number of repetitions (P3). The interaction would have effects on mobility because the concrete targets, i.e. the cards to be reached, would prevent powerless and listless movements (P1). The stretching would train the flexibility of the chest and spine, which in turn would support breathing (P1). At the same time, balance and coordination are trained (P1). The design as a competition could additionally increase motivation and the new and interactive approach could create more interest in using it (S2). One respondent noted that the application was not only suitable for Parkinson's patients but could also be used for patients with hemiparesis or for neurological patients (P2).

In addition, the interviewees mentioned several tangible suggestions for improvement of the interface and the game mechanics during the evaluation, which would go beyond the scope of this paper to mention them all, but which were implemented additionally after the interviews.

4 DISCUSSION

The aim of the work was to develop a concept for an exergame for Parkinson's disease patients with mild to moderate Parkinson's disease to improve hypokinesia and fatigue. The interaction with this exergame is made via optical body tracking through the *Azure Kinect* without additional devices like controller or physical marker.

The interview results show that the lack of motivation, which is often caused by the disease (Hagell & Brundin) but also by the repetitive nature of the therapy (Fox et al., 2012), is a common problem in Parkinson's therapy. Due to their

motivating nature, serious games are suitable to be used as a therapy addition (Rego et al., 2014). Serious games offer a very high potential, but some requirements and challenges have been identified for their use as a therapy supplement for Parkinson's patients.

This includes choosing an appropriate theme for the target group, therefore a gardening theme was chosen that appeals to the target group (McNaney et al., 2015; Othlinghaus et al., 2011) and is associated with relaxation (Scott et al., 2015). The adaptability to the abilities of the respective players is realized through different play modes (sitting/standing), hand selection and calibration through arm span of the players. In order to visualise the body movements to recalibrate body awareness (Berardelli, 2001) the three-dimensional skeletal representation detected by the Kinect body tracking is displayed parallel to the game. The last requirement mentioned in the interviews was the possibility for players to take a break at any time. In the concept developed, this is made possible by the fact that the players themselves interact proactively with the game and do not have to react to the game. The game can be paused and, in the event of severe exhaustion, also be stopped at any time.

Obstacles identified in the interviews of the requirements analysis were a possible scepticism of the patients towards the new technical application, which should be overcome by using a familiar casual game concept (Nap et al., 2009) and an appealing theme (Othlinghaus et al., 2011). As requested in the interview, the focus is diverted from the (motor) competition in order to avoid demotivation and overexertion. For this reason, the *Matching Pairs* concept, which challenges the visual-spatial working memory, was chosen. The high interdependence of the players in this concept ensures social connections (Depping et al., 2018) and thus higher motivation (Ryan & Deci, 2000).

The LSVT BIG training was named as a therapy concept suitable for transfer to a digital therapy support, which is used to improve hypokinesia (Fox et al., 2012), which is also the aim of the application. The basic idea of this training concept of wide and flowing movements was adopted and combined with a competitive game design of *Matching Pairs*.

In the expert interviews evaluating the concept and the prototype, the application was rated very positively and as suitable for supporting the therapy of Parkinson's patients. The expert interviews were conducted as a formative evaluation and were well suited to identify areas for improvement and further research potential. Unfortunately, it is not possible to make any substantiated statements about the player's experience, as the test persons were only able to view screenshots and videos of the application. In order to finally evaluate the usability and effectiveness of the application, the comparison of objective health variables by means of standardised measuring instruments of a user group with a suitable control group is necessary. In addition, individual experience reports of the test persons should be collected (Kato, 2012). Unfortunately, this kind of testing was not possible due to the current pandemic situation, but it will be carried out as soon as possible. However, the interviews revealed some potential for improvement of the current prototype in the sense of a formative evaluation, which can be implemented or further investigated in the future.

Limitations for the results of both qualitative studies are the small sample sizes. Unfortunately, the corona pandemic has made a laboratory study for evaluation impossible, which makes the significance for interaction assessment very weak. A patient perspective on the prototype would have further enriched the evaluation, which will be included in further studies.

Overall, the results support the assumption that a serious exergame can be a suitable therapy supplement for Parkinson's patients and some characteristics for a suitable application could be identified. In any case, further studies are needed to evaluate training effects and to obtain assessments of the prototype by patients and potential users. These are planned for the near future.

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