EAI Endorsed Transactions
on Serious Games

Research Article ICST.ORG

Rehabilitative Games for Stroke Patients

A. Pyae[1], M. Luimula[2,*] and J. Smed[1]

[1]University of Turku
[2]Turku University of Applied Sciences

Abstract

Stroke is one of the major problems in medical and healthcare that can cause severe disability and death of patients especially for older population. Rehabilitation plays an important role in stroke therapy. However, most of the rehabilitative exercises are monotonous and tiring for the patients. For a particular time, they can easily get bored in doing these exercises. The role of patient's motivation in rehabilitation is vital. Motivation and rehabilitative outcomes are strongly related. Digital games promise to help stroke patients to feel motivated and more engaged in rehabilitative training through motivational gameplay. Most of the commercial games available in the market are not well-designed for stroke patients and their motivational needs in rehabilitation. This study aims at understanding the motivational requirements of stroke patients in doing rehabilitative exercises and living in a post-stroke life. Based on the findings from the literature review, we report factors that can influence the stroke patients' level of motivation such as social functioning, patient-therapist relationship, goal-setting, and music. These findings are insightful and useful for ideating and designing interactive motivation-driven games for stroke patients. The motivational factors of stroke patients in rehabilitation may help the game designers to design motivation-driven game contexts, contents, and gameplay. Moreover, these findings may also help healthcare professionals who concern stroke patient's motivation in rehabilitative context. In this paper, we reported our Virtual Nursing Home (VNH) concept and the games that we are currently developing and re-designing. Based on this literature review, we will present and test out the ideas how we can integrate these motivational factors in our future game design, development, and enhancement.

Keywords: rehabilitation, motivation, digital games, human-computer interaction, user requirements.

Received on 06 February 2015, accepted on 24 March 2015, published on 03 July 2015

doi: 10.4108/sg.1.4.e2

1. Introduction

Stroke is one of the major medical and healthcare problems that can cause severe disability, partial paralysis, memory loss, and even death of sufferers. According to Burke et al. [1], 85% of patients live with impaired upper and lower limbs after suffering from stroke. The World Health Organization (WHO) states that every year there are 15 million people who suffer from stroke in the world. Among them, 5 million patients die and another 5 million are living with permanent disability that negatively impacts their quality of life. Stroke survivors may experience limitations in range of motions, fine motor skills, gross motor skills, reaching, and manipulation. These deficits can dramatically change the patient's daily life that has to be dependent on others (e.g., family members or caregivers) in doing personal management such as showering, feeding, changing clothes, house chores, and ADL (Activities of Daily Living) tasks. Because of these physical limitations after stroke can reduce patient's participation in social and leisure activities, community programs, and work activities [2]. As a result, it may lead to depression, social isolation, and loneliness in life. Rehabilitation training, in which repetitive exercises are involved, can help the stroke patients with motor impairments of lower and upper limbs to overcome the physical limitations following stroke [2]. Rehabilitation is the essential part of

*Corresponding author. Email: mika.luimula@turkuamk.fi

the stroke recovery for stroke survivors because repetitive and rehabilitative exercises can support the brain to get sufficient stimuli to remodel and to regain better motor control. Moreover, rehabilitation can help the patients retrain their functional abilities in walking, transferring, balancing, and doing ADLs.

However, stroke therapy involves daily rehabilitative exercises, which include repetitive movements of the affected limbs. Patients typically complain that these exercises are monotonous, tiring, and boring. Chang et al. [2] pointed out that only 31% of patients who have post-stroke motor deficiencies perform the therapeutic exercises as prescribed by the physiotherapists. Early termination of stroke rehabilitation may lead to permanent disability in life. Motivation and therapeutic outcomes are strongly linked [3]. Healthcare professionals generally believe that patient's motivation plays an important role and it can largely determine therapeutic outcomes. There are other factors that can negatively impact on the patient's motivation in rehabilitative process such as lack of social support from family members and friends, expensive fees of stroke therapy, difficulty in travelling to rehabilitative center, and lack of caregiver who can look after them.

2. Background

Recent studies show that healthcare professionals are more and more interested in using computer games for stroke rehabilitation [1]. In general, video games are known to be an engaging platform for the players and gamers because of entertaining, motivating, and fun activities. Virtual rehabilitation has received a great interest from many researchers and healthcare professionals because it can provide a real world environment (e.g., tennis court in sport game or ski resort in leisure game) where players can forget about their surroundings and situation and pay attention to a task in a simulated virtual environment [5]. By playing digital game-based rehabilitative exercises, stroke patients may have improvements in the upper and lower limb mobility as well as higher level of motivation and fun. Among the commercial games available in the market, Nintendo Wii seems to be the most promising technology to be used as a therapeutic tool in stroke rehabilitation. Because of its low-cost hardware and physical game activities, many researchers have tried to use Wii games in stroke therapy. Basically, Wii encourages game players to use physical movements and natural actions in gameplay (e.g., playing tennis in Wii Sports). It has gained positive feedback and support from the therapists because of its ease of use, entertaining game contents, and a wide variety of games available which can help patients to perform therapeutic training and physical exercises [6]. Although Nintendo Wii is useful and usable in rehabilitation, there are some usability issues that can be critical to the patients who play the games for rehabilitative purpose. For instance, the players cannot customize the level of difficulties in the game itself to meet the needs of different levels of disability. Besides, it does not convey therapeutic feedback to the patients and it does not monitor the patient's progress in every session. The other game consoles available in the market such as Microsoft Xbox, Sony PlayStation, and Eye Toy are also not designed for rehabilitation and therapeutic training because these games are only targeted for young and healthy users. Furthermore, these games are mainly for fun, entertainment, and recreation. The game content in these game systems is not targeted for stroke patients. Thus, physical movements in the gameplay are difficult and not suitable for stroke patients. As these games are solely aimed for healthy players, the motivational content of the games is also not suitable for the motivational needs of the stroke patients. Therefore, all these gaps between rehabilitative and motivational needs of stroke patients and existing gaming technologies should be bridged. In this study, we aim at understanding and having empathy on the needs of the stroke patients' motivation in rehabilitation for designing rehabilitative games for them.

3. Motivational Factors

To design and develop interactive motivation-driven games for stroke rehabilitation, it is important to understand and to have empathy for the problems, needs, motivation, pain points, and goals of stroke patients. In this study, we conducted a literature review to explore and to understand the motivational factors that can influence stroke patients in rehabilitation. According to the literature, there are many factors that can have an impact on the stroke patients' motivation in doing rehabilitative exercises and living post-stroke life positively. Social and emotional support from family members, patient-therapist relationship, role changes in family, understanding in rehabilitative process, long and short term goals, and music are some of the important motivational elements that can affect the patient's level of motivation in performing and continuing their rehabilitation that can lead to faster recovery from the stroke. Motivation has been variously described in terms of innate and internal drives or needs, inner stimuli and responses, and goals or the directions of the motivation. The motivation concerns the intrinsic and extrinsic conditions responsible for variations in the intensity, quality, and direction of on-going behaviour [7]. To understand a patient's motivation, one must also consider the environmental pressures that can impact on the patient and include the demands of his or her condition after stroke. In fact, there are environmental factors associated with most of the patients' needs or drives. Research on the stroke patients' motivation is necessary to focus either on the inner needs of the patients, or on the environmental pressures and demands.

3.1. Social Functioning

Social functioning such as social support, social contact, and social integration, plays in an important role for the post-stroke patients. Social contact and social support may not only improve the physical recovery of the patients but also enhance the level of motivation in rehabilitation. Moreover, it may encourage the stroke patients to actively engage in the rehabilitative training. Patients who receive social support from family members are likely to get higher motivation in rehabilitation. In contrast, socially isolated patients are likely to have less motivation in rehabilitation and they are pessimistic about the post-stroke life. Dombovy et al. [8] state that stroke rehabilitation is the combination and coordination of social, medical, educational, and vocational measures for training a patient to regain the highest level of functional recovery and ability. They continue to say that encouraging the socialization of a stroke patient is one of the factors of well-established principles of rehabilitation for stroke. Santus et al. [9] point out that the family is a natural source of social support for a stroke patient and it may influence his or her functional recovery by providing companionship and an opportunity for a normal life. They highlight that the rehabilitation program should emphasize not only the training for physical improvement but also education of family members and society how to support the patient socially and physically. Deteriorating relationships after the stroke are common phenomena for the stroke patients and social communication remains the most stressful issue. Changes in social activities, vocational interests, and role assignments also affect the family system of a stroke patient. Barry [16] points out that stroke patient's expectations on one hand and his or her significant others' expectations on the other hand can strongly influence on his or her level of motivation. The people who play a key role in the stroke patient's rehabilitation are not only the therapists but also his or her family members, friends, associates in whatever situation or setting he or she may live and work.

Evans et al. [11] advocate that social support and functional rehabilitative outcome after stroke are positively linked, suggesting that the support and involvement of family members in rehabilitation are important to speed up the recovery from the stroke. Although family encouragement was one of the factors that can positively affect the stroke patient's motivation, pushing too hard to make improvements in rehabilitation can lead to lower level of patient's motivation in therapeutic training [3]. In addition to this, overprotection can reduce the patient's level of motivation. Social connection with family members and friends is an important factor for patients after stroke but it is very challenging for them to communicate with other people such as understanding what people say, expressing their emotions, talking to other people, walking, eating out, and shopping. It can make the stroke patients feel depressed, discouraged, disconnected, and isolated at a time when they need more social support from family members, friends, and relatives [10]. It is true to say that everyone needs social support and stroke patients cannot be excluded from their social needs. There are many ways that family members and friends can socially support the stroke patients such as companionship from family members, peer's support in rehabilitation, sharing information about stroke rehabilitation and recovery, trying new things for them, listening to their concerns and frustration, sharing their stories, keeping connection with old friends, helping in social outing, participating in social events and activities, and making new friends. Shimoda and Robinson [12] state that a lack of social support can prevent the stroke patients from regularly attending rehabilitative training or lead to a lack of motivation in doing rehabilitative exercises. Most stroke patients can get their motivation through interaction with their beloved ones such as playing with their grandchildren (e.g., intergenerational games), eating out with partners, going cinema with their friends, and socializing with neighbors [13]. Krause et al. [17] states that in general, social support covers the terms such as affective support, information support, and tangible support [17].

3.2. Patient-Therapist Relationship

One of the most important motivating factors is the use of the therapist's relationship with the patient as a form of bringing about the patient's recovery, readjustment, and rehabilitation after stroke [16]. The relationship between the stroke patient and the therapist forms one of the motivational elements in rehabilitation. Maclean et al. [3] mention that if a therapist has low expectations of how a patient will perform in rehabilitative tasks, it may cause a negative effect on the patient's motivation. Positive feedback, support, and encouragement from the therapist are important for the stroke patients to gain confidence and positive emotions in rehabilitation. The therapists can encourage stroke patients to feel more confident and motivated to continue to do rehabilitative exercises in the process of stroke recovery whereas giving confusing messages to the patients about the role of therapists in rehabilitation could lead to unnecessary misunderstanding in therapy and it may negatively impact on the patient's motivation in continuing rehabilitation process. The therapist can increase the motivation of stroke patients by striking up a rapport with patients and discussing about their lives before and after stroke [3]. Generally, the therapists not only help the patients improve in physical rehabilitation but they can also consult the patient's social and family issues. Therefore, the relationship between therapists and stroke patients are crucial in stroke rehabilitation.

3.3. Setting Relevant Rehabilitative Goal

Post-stroke rehabilitation is described as a long-term process where the patient and the healthcare team try to get an agreement on the activities to be focused and the

goals to be achieved through interaction, negotiation, and collaboration between the stroke patient and the healthcare professionals such as doctors, therapists, and caregivers. Setting a relevant rehabilitative goal can positively impact on the stroke patient's motivation. However, the goals should be meaningful, realistic, achievable, and measurable. The smaller goals for stroke patients should be related to real-life goals which are meaningful, achievable, and realistic. Moreover, the personalized rehabilitation goals may enhance the level of motivation of stroke patients in rehabilitation. These personalized goals may vary from patient to patient. For example, a particular stroke patient may want to re-enter into the working life or to drive a car when he or she recovers from the stroke whereas another stroke patient may want to be more independent in doing ADLs. Therefore, a goal that can link to individual needs and wants may positively impact on the stroke patient's motivation and engagement in rehabilitation. Therapists and caregivers need to help the stroke patients to achieve the smaller goals of therapy such as better movements of limbs followed by the bigger goals such as re-integrating into community and going back to work [13].

3.4. Rehabilitative Setting and Environment

Rehabilitative environment is regarded as one of the important factors for patients' motivation in rehabilitation. Generally, it involves well-designed and patient-friendly rehabilitation room, communal meals, and group training sessions where the stroke patients can share their experiences about rehabilitation and learn each other's progress in training, are the positive factors of motivation that fasten recovery from stroke. Almost every stroke patient has to go through a rehabilitation process after they have gone through an acute hospital. They have to spend most of their time at a rehabilitation centre before they regain the functional abilities of the impaired limbs. Therefore, the role of the rehabilitative environment such as a rehabilitation training room, a setting of the gymnasium, and people in this environment, is important for the stroke patients to feel comfortable, convenient, and secure. In addition to personal factors such as health history and condition, gender, role changes in family, sex, social background, and educational background, individual patient's motivation may be impacted also by environmental influences that involve physical condition, social and emotional condition, and individual attitudes for rehabilitation [18].

3.5. Information from Healthcare Professionals

Highly motivated patients feel that education and information provided by the healthcare professionals can change their thinking about therapy. They may see it as not only a helpful solution but also the necessity of an important role in stroke rehabilitation [14]. Before a particular patient starts his or her rehabilitation program, it is important for the therapists to explain the information about rehabilitation and therapeutic exercises. In this way, the patients can understand the process of rehabilitation and the benefits of the exercises. Moreover, understanding the process of rehabilitation and its benefits can enhance the patients' level of motivation and engagement in rehabilitation. The information of rehabilitation process from the therapists and their explanation are important for the stroke patients to understand their condition, process, and progress very well, and which may lead to a higher motivation in rehabilitation and faster recovery from stroke.

3.6. Meaningful Rehabilitative Task

Occupational therapy (OT) includes relearning skills for doing activities of daily living for the patients to get independence in their daily lives. For example, personal grooming, showering, toileting, meal preparation, and money management are some of the ADL tasks in occupational therapy. These OT exercises are meaningful and they reflect the social lifestyles of the stroke patients. By doing activity based exercises (e.g., ADL-based rehabilitative exercises), the patients may feel motivated and more engaged in the exercises. Flores et al. [15] advocate that meaningful tasks should be integrated into the rehabilitation. By doing meaningful rehabilitative tasks, patients can get a direct relationship between the use of impaired limbs in the therapeutic training and the use in their activities of daily living.

3.7. Individual Needs and Customization

As motoric impairment can be different from one patient to another, successful rehabilitative program requires personalization or customization for the individual patients to address their problems, to meet their needs, and to adapt individual's motoric level. Adaptability is one of the important factors for individual patients so that the difficulty level can be increased when the patient's motoric abilities improve in a particular period [15]. Understanding individual stroke patient's needs, focusing on personalized or customized motivation, looking beyond simple fun elements to provide engaging and correct upper or lower limb movements and activities are the difficult challenges in stroke rehabilitation.

3.8. Positive Feedback from Therapist

The encouragement from medical professionals such as doctors, therapists, and nurses, plays a vital role in stroke rehabilitation. Often, the therapists have to not only explain the information about rehabilitation but support them with positive feedback so that the patients can feel more confident, motivated, and engaged in what they are

doing. The feedback from the therapist to the patients should be positive to encourage them to actively engage in the rehabilitation. It may help them feel more motivated in performing the rehabilitative tasks and encourage them to be more engaged, active, and confident. Feedback plays an important role in rehabilitative training to maintain and sustain the motivation of individual patient during the rehabilitation process. Extrinsic feedback or external response can encourage the persistence to perform better in a situation of physical education [19].

3.9. Music for Rehabilitation

Everyday many people expose music for different reasons such as relaxation, interest, and motivation. Generally, people use music to achieve different types of goals in everyday life such as to motivate in doing exercises, to get relaxation, to pass time when driving for long hours or taking bus for long distance. Music is an interesting area for the healthcare professionals and researchers to study on how it may affect the stroke patient's motivation in therapeutic way. Music therapy may be effective in reducing negative emotions such as anger, depression, and anxiety, whereas promoting positive affections such as happiness, joy, and pleasant. Music Therapy can be used as listening therapy for the stroke patients to listen to a list of songs that caregiver or music therapist has selected for them to match a mood or to bring back memories [13]. Music can trigger the positive emotions of the stroke patients that may lead to more engagement in doing rehabilitative exercises. Music can be used as a healing tool in the social and personal context that can have a positive impact on the emotion of individual patient who is recovering from a stroke. Moreover, it can enable social interaction between the therapist and the patient or among a group of people in a rehabilitative training session [20]. Music may affect the physical, mental, and social components of the post-stroke rehabilitation process in many ways such as therapeutic listening and rhythmic movements.

3.10. Recreational Activities for Stroke Patients

Recreational activities such as playing digital games or board games, singing songs, participating in social outings, and going out for shopping, are recognized as motivational elements for the stroke patients that enable better social connection and re-integration with peers, friends, therapists, and communities. By participating in recreational activities, the stroke patients may regain a sense of social reintegration and better social ties with other people. Moreover, it may overcome the issues of social isolation and depression and it may help the stroke patients to feel more motivated in rehabilitation training and improve their quality of life. There are many benefits of leisure activities that can positively affect individual well-being and quality of life. Recreational activities also help the stroke patients to enhance their physical and mental health condition, together with personal growth and social communication. Leisure activities are suitable for everyone who can experience positive moments from doing these activities regardless of what state of health he or she is in. While the types of the recreational activities a person has done before the stroke might be different from the leisure activities that he or she is currently doing in post-stroke life, the feeling of wellbeing that one gets from these recreational activities will not be different [21].

4. Game Design Principles

Understanding the stroke patient's motivation in doing rehabilitative exercises is an important step in designing digital games for stroke patients and rehabilitation. Thus, the findings from understanding motivational elements of stroke patients in rehabilitation can be applied as design inputs and considerations in the game design process. According to the literature review, social functioning such as social ties with friends, peers, and family members and social communication, is one of the most important motivational factors for the stroke patients to get motivated in doing the rehabilitative exercises which is why it is one of the most important design inputs for designing a game for stroke rehabilitation. In designing a digital game for rehabilitative purpose, we can design multiplayer game where two or more players can play the game together so that they can socially connect with each other through the gameplay. By playing multiplayer games, the stroke patients can build up the social ties with peers and have a mutual understanding between patients in a similar situation. Moreover, not only the patients but also the therapists or other healthcare professionals can monitor or even participate in the multiplayer game. To achieve the idea of improving socialization of the stroke patients, we can also design intergenerational games for them to maintain the social connection between the patients and their family members. According to Llyod [24], intergenerational communication between older adults and younger generation can decrease the prevalence of ageing and it can considerably support to improve the mental health and physical well-being amongst the elderly group. With regard to the digital game-based socialization, Theng et al. [25] insist that generally computer-mediated games can provide inter-generational gameplay (e.g., Multiplayer Sport Games). Moreover, it can support entertaining and socializing features that are used as tools to promote positive mental health, social health, and physical well-being of the older adults. To design digital games for stroke patient's rehabilitation, the concept of "Patient-Therapist relationship" can be used as a basis for the relationship

between virtual therapist and the player. Virtual therapist can be a narrator or a virtual coach in the rehabilitative training in the game itself. In addition to this, the customization of the avatar's identity selected by the player can be integrated in the game so that the player may have stronger connection to the virtual therapist in the game. According to Kenny et al. [26], Virtual Human Agent technology has been used by the researchers to develop 2D or 3D characters that are used in virtual reality games and applications. For example, these virtual characters can be designed as virtual therapists, virtual nurses, and caregivers in the context of stroke rehabilitation.

With regard to the setting a relevant and achievable goal in the rehabilitation, we can account this as a goal-based game for the stroke patients. It is important that the goals are realistic and achievable and meet the individual's needs. In designing a goal-based game, we can allow the player to set a particular goal to achieve at particular levels or to get certain ranks or to earn certain points or scores in the game. In this way, the player can feel more motivated and engaged in the gameplay. Well-maintained and clean rooms, friendly social interaction, and stroke patient friendly facilities are amongst the important settings in the rehabilitative context that can have an impact on the level of motivation. For the game design, game environment or context should be more realistic and familiar to the players and should reflect their social lifestyle. By designing a game environment reflecting the stroke patients' social lifestyle, it can help them to feel more engaged in the game itself, which can improve the level of their motivation. For example, we can design a virtual shopping game environment in which the players can do shopping activities that they used to do before the stroke. Pyae et al. [27] advocate that in designing game for stroke patients, game environment should be meaningful and it should reflect the player's social background.

Information provided by the healthcare professionals such as doctors, therapists, and nurses, is important for the stroke patient in stroke rehabilitation. In the game design, we can use this concept as a help system; for example, virtual training by a virtual therapist, and information provided by a virtual nurse or caregiver on how to conduct the game. In addition, a virtual character (e.g., virtual therapist) can provide the progress of the gameplay, game scores, and game incentives in real-time during the gameplay. Physical therapy focuses on regaining strength and mobility of the upper or lower limbs by doing therapeutic exercises whereas occupational therapy focuses on relearning real activities (e.g., ADL, community reintegration, personal management and cognitive skills) that a patient has lost after suffering from the stroke. These ADL-based tasks are basically meaningful and realistic to the patients. In a game environment, we can also include real world tasks in the game activities. For example, we can design a cooking game for the stroke patients where they can prepare and cook the meal and at the same time, they perform therapeutic movements followed by cognitive skills such as choosing the right ingredients for the food and manage the cooking time. Furthermore, we can design a game that based on real-world activities such as simulation for driving a car, virtual shopping tasks, use of mobile phone or ATM or public phone, purchase of a public transport ticket, and other social activities. According to Pyae et al. [27], by playing meaningful game tasks, the stroke patients may feel more engaged, motivated, and active in the rehabilitative training.

In stroke rehabilitation, the individual needs may vary from patient to patient. Thus, the therapists and nurses have to customize the rehabilitation based on the individual requirements and goals. As a game design consideration, it is important to implement the player's personalization and customization in the game itself such as user profile, game levels, game scores, and ranks. When designing games for stroke patients, we can customize the game-based therapeutic activities or tasks to reflect the individual needs and resistances such as strength, mobility, and endurance of upper limbs. User profile, avatar customization, and game level setup (e.g., easy, hard, and master) can be included in the game design which allows the therapists or the patients to customize the games to meet their individual needs. By achieving certain levels the players may feel more engaged and motivated in the gameplay. Real-time game feedback is considered as one of the most important elements in general game design. In stroke rehabilitation, positive feedback from therapists in rehabilitative training should encourage the stroke patients. In the game design, it should emphasize giving positive and encouraging feedback such as progression level, positive feedback in audio or visual display by the game itself, and certain scores as incentives for the players in whatever situation they are. By getting encouraging feedback or incentives from the game, the players may actively involve in the gameplay and it is bound to increase their level of motivation. Music therapy is helpful for stroke survivors not only for entertaining but also for therapeutic purpose. Since music can be used as an emotionally stimulating tool, music therapy can also help to enhance or maintain one's mental health and physical well-being, communication, social well-being, and quality of life [23]. The role of music is vital in designing digital games. The background music and audio feedback form important game elements to judge if a particular game is interactive, engaging, and enjoyable. When designing and developing interactive games for stroke patients, it is important to choose the right genre of music and audio feedback so that the patients feel more engaged and active in the gameplay. Finally, recreational activities (e.g., chess games, singing games, shopping games, card games, and puzzle) can be integrated into the game design to improve the stroke patient's motivation in the gameplay.

Table 1. Indication to the game design principles

Motivational Factors	Game Design Consideration
Social Functioning	• Multiplayer game • Intergenerational game • Virtual friend • Video chat in game • Social-networking game
Patient-Therapist Relationship	• Virtual therapist • Virtual nurse • Virtual Coach
Goal Setting	• Level design • Perceivable and achievable goals
Rehabilitative Setting and Environment	• Game theme and scenery • Difficulty of the game • Complexity of the game
Information from Healthcare Professionals	• Game tutorials • Game introduction • Help system • Computer-controlled assistant

After considering all the motivational factors that can have an impact on the stroke patient's level of motivation and rehabilitative outcome, we can suggest game design guidelines and ideas for designing and developing interactive games for stroke patients and rehabilitation. Table 1 lists the motivational factors of stroke patients and game design inputs and considerations for the game designers.

5. Gamified Solutions in Healthcare (GSH) - Virtual Nursing Home (VNH)

In our ongoing project called Gamified Solutions in Healthcare (GSH), we are developing services and solutions for elderly people through gamification or game-based activities. One of the goals in this project is to design and develop a Virtual Nursing Home concept. This conceptualization should offer alternative solutions for providing elderly's self-care, preventing elderly from loneliness and social isolation, and easing the healthcare professional's work load. Virtual Nursing Home (VNH) concept has been planned and designed with a close collaboration with Serious Games Finland, Puuha Group, and also with other public and private sector partners in Finland such as City of Turku and Attendo Oy. Basically, this concept includes four service areas: Socialization, Entertainment, Rehabilitation, and Counseling. These service areas have been conceptualized, designed, and analyzed based on our findings from the literature review, related studies, review of existing games, consultation with partnered organizations, and observational study at elderly service homes in Finland. At the initial stage of the study, we conducted the literature review study that covers the usability and usefulness of existing technologies, commercial games and our existing and on-going games, socialization and physical rehabilitation of elderly, and motivational factors for elderly in their rehabilitation. In this paper, we report the importance of motivational factors for elderly and how we can integrate these findings into our current and future games for VNH concept. Figure 1 mentions the conceptual diagram of Virtual Nursing Home.

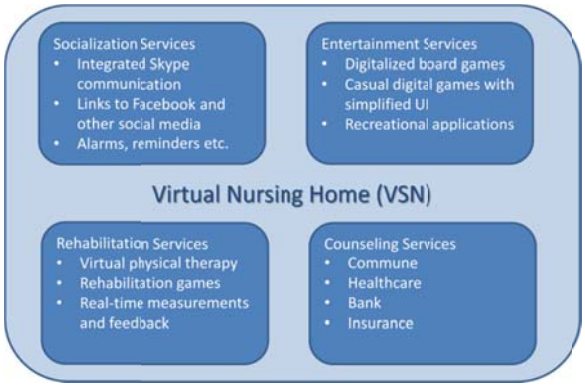

Figure 1. Overview of Virtual Nursing Home concept

We have started to design and develop the VNH system concept by using User Centric Design (UCD) and rapid prototyping research methods. UCD is defined as multidisciplinary design approach based on the active participation of targeted users in the design process for an in-depth understanding of users and their requirements. Design and evaluation processes can be iterative whenever it is necessary [28]. The rapid prototyping stage includes an early iteration loop that uncovers insightful feedback and ideas on system, technical design, interface issues, creativity in the system, and effectiveness of system's instruction [29]. UCD includes different stages: user requirements, requirements specification, prototyping, and evaluation. In this project, we will use rapid prototyping technique when we have information about functional and system requirements. With regard to the concepts that we have adopted in VNH system, the social services in the VNH system should bring new social tools especially for isolated patients to receive the social support not only from family members, relatives, and friends but also from doctors, therapists, and nurses. The examples of social tools are live video chat, reminder or alert system by family members or healthcare professional (e.g., to take medicine on the prescribed time, to take meal on the regular time, and to motivate elderly to do physical exercises), and monitoring system such as fall detection, movement detection, and emergency call. The social service tool should be able to integrate video and live chat system (e.g., Skype), elderly friendly social network tools, and powerful motion detection sensor (e.g., Microsoft Kinect). The concept of

rehabilitation services in VNH is to provide elderly people game-based physical activities for improving their physical well-being and promoting their daily or weekly exercises. Moreover, this concept aims at helping therapists or caregivers at the elderly service homes in Finland to reduce their workload in terms of rehabilitative and physical training for elderly. The concept of entertainment services that we planned in VNH is to support the elderly recreational and leisure activities that are needed in old age. The current practices that elderly perform at the service homes in Finland are group activities such as dance-along session, board games, sing-along, and arts-and-crafts. In VNH, we intend to create game-based digital recreational activities for the elderly to enhance their recreational and leisure experiences in their daily lives. The last concept in VNH system is counseling services that provide elderly variety of services such as healthcare, safety, banking, and insurance. To shape this concept, we are aiming at providing on-line based counseling sessions for elderly when they need to get it.

For the concept of social services, we have recently developed a social-based system which is called "Old Photos on Map Application". The main idea of this application is to maintain elderly's memories in their younger years and to enhance their positive emotions (e.g., happy, content) by showing personalized old photos on the digital map over the digital device such as mobile, tablet, and desktop. According to our previous study [30, 31], we have experiences to utilize old photos as an efficient way of storytelling for elderly to reflect their social background and memories and to enhance their socialization. We are now planning for our first user testing with older adults to understand the usability and usefulness of this system and how it can socially impact on the elderly and their emotion. Based on the findings from our future user testing, we will decide how we can integrate this system into our main concept of social services in VNH system.

In VNH system, Entertainment and Rehabilitation are the two important services. To achieve both concepts of entertainment and rehabilitation, we aim at designing and developing digital games that will address the needs of elderly's physical and recreational activities. At the early stage of this project, we are partnering with two organizations, Serious Games Finland and Puuha Group. Both of them are largely working in the area of serious gaming and digital games. The collaboration between our project and Serious Games Finland is to investigate the usability and usefulness of Kinect for Xbox One which is the newest version released from Microsoft. Currently, we are trying to test the commercial games that use Kinect as a motion sensor and how effective and efficient it is for elderly players. We are also testing the features provided in the up-to-date version of Kinect. In the spring 2014, we have tested with a few older adults by letting them play Kinect-based Xbox games to understand how effective and efficient Kinect for elderly is. In a close cooperation with Serious Games Finland, we are currently studying on virtual physical therapy solutions that can interpret the physical therapy and exercises movements. We are currently developing quick prototypes namely virtual swimming and seated exercises by utilizing exercise library. Once we have done these games, we aim at running pilot test with elderly to understand its usability and usefulness.

In addition, we are also closely working together with Puuha Group Finland. Basically, Puuha Group is designing and developing digital games for playground and public places with physical instruments or equipment. Their idea is to install such digital games with physical equipment in the playgrounds and public spaces in the neighborhood in Finland for people's physical well-being and recreational activities. We are also planning how we can adopt this idea in VNH concept and how we can deploy such games in real nursing homes or elderly service homes. Therefore, we are currently reviewing the existing games designed by Puuha Group whether these games are suitable and adaptable for elderly and improve their physical activities. The games that Puuha Group has developed are SportWall or PhysioWall and Resiina. All these games are targeted for physical activities of players but they are not targeted for elderly players. Thus, we are trying to test these existing games with old users whether they are elderly-friendly. Other than Finnish collaboration, we are also working with Japanese researcher in the area of digital games for elderly and healthcare. One of our visiting researchers has developed a game called "Top 100 Mountains game" that will be a totally new game which has some similarities to SportWall by Puuha Group but we will be focusing on Japanese culture (e.g., Samurai, Japanese Mountains, Shrines) because we have intention to conduct cross-culture test between Finland and Asian countries (e.g., Japan, Singapore). In this paper, we have reported a list of motivational factors for elderly and their rehabilitation. Since motivation plays a key role in rehabilitation, it is important to know how we can adopt these motivational factors in designing and developing games. We are currently at the stage of developing new games (e.g., Kinect-based games and Exercise Library with Serious Games Finland) and re-designing current games (SportWall or Physio Wall with Puuha Group). Therefore, we are developing the ideas of integrating motivational elements in the game design and gameplay. For example, we can design multiplayer games or intergenerational game to enhance the socialization of elderly player. We can design effective game level design from novice to professional player. Moreover, positive feedback, personalization, game music, game incentives, and game environment are also important motivational elements that need to be taken into consideration for game design and game play.

6. Preliminary Findings from Pilot User Testing

Based on the objectives of VNH project, it is important to investigate the usability and usefulness of existing games whether if they are suitable for elderly and for their physical activities and rehabilitation. Therefore, we conducted a pilot user testing with elderly participants who resides at the service homes or elderly homes in Rääkkylä, in the eastern part of Finland. We recruited five elderly participants who are physically and mentally sound, fairly active in exercises, and regular visitors to the service home. In this study, we selected non-commercial game, Puuha Group's SportWall, and commercial games; XBOX's climbing game and PS3's Tennis game respectively. Xbox's climbing game used Microsoft's motion-based Kinect sensor to play the game. PS3's Tennis game used PlayMove controller to interact the game while Puuha's SportWall used the traditional webcam to track the player's movements. The reason why we selected these games was to investigate the difference of usability and usefulness between commercial and non-commercial games. Besides, we would like to find out the usability of multimodal input devices that we used in this study. Basically, the commercial games are targeted for entertainment and for younger players. However, Puuha's SportWall game is designed for physical exercises and for various age groups. Therefore we tried to investigate whether the commercial games are suitable for elderly and their physical activities. Beside, we would like to find out if the non-commercial game, Puuha's SportWall, is also suitable for elderly players and their rehabilitative exercises. In this user testing, we let the individual elderly play a game in each game session. Before they played the game, we asked their consent to participate in this user testing. After that, we briefly explained the individual participant how to play the game by doing a game demonstration. All the elderly participants in this study lacked the prior experience in playing digital games. Thus, we assisted them in their first try so that they could easily perform the actual gameplay. In session one, the elderly participant had to play Xbox's climbing game. The gameplay took about 5 to 8 minutes followed by a quick questionnaire session that investigated their feedback towards the usability of games, input device, and their experiences in the particular game session. In the second game session, the elderly participant had to play PS3's tennis game followed by Puuha's SportWall game in the third session. We used the same procedures in all three sessions. After finishing all sessions, we conducted a quick follow-up interview session with the elderly participant to get their feedback on the overall gameplay experiences in this usability testing. The usability testing for each participant took about 30 minutes and the whole user testing took about 3 hours. In this study, we basically gathered the elderly participants' feedback towards the usability and usefulness of three game, interactive input devices, and their overall experiences. After collecting the elderly participants' responses, we compared the ease of use of commercial Xbox's Climbing game and PS3's Tennis game with SportWall game. Moreover, we compared the ease of use of multimodal input devices that were used to interact with the games.

Based on the feedback made by the elderly, we noticed that commercial games are hard for the elderly to play in terms of their user interfaces, graphics, and gameplay. Commercial games are typically containing too much information on the user interface such as graphic, text descriptions, and background music that are not suitable for the elderly. Most of the commercial games focus more on young and healthy players. Therefore, their game designs and interfaces are too much fanciful and complex for older players. Furthermore, these games cannot be customized for older players to adjust their limited mobility and movements. Based on the findings from the user testing, we have found out that most of the elderly participants in this pilot study could not follow the instructions given in the commercial games. Since they could not customize the game to meet their needs in mobility and physical movements, most of them did not complete the first level and they felt a bit frustrated to play it again. Besides, the feedback (e.g., scores and labels) in the game were lacking the motivational and encouraging messages to the elderly. Moreover, the feedback in the game was less appealing and not intuitive enough for the elderly player. Apart from the difficulties they have encountered in the gameplay, the elderly participants mentioned that they were interested in playing commercial games as their leisure activities as well as physical exercises. For example, they liked the idea of sport activities such as Climbing and Tennis games.

In contrast to the commercial games, the elderly participants gave the positive comments on the SportWall game. For example, they mentioned that the user interface of SportWall is simpler and cleaner than the commercial games. Therefore, they could focus on the game tasks with less distraction in the gameplay. The text descriptions in SportWall game are simple and visible enough for the elderly to see. As a result, they could follow the instructions to play the game easily. The personalization supported by the game could help the elderly to easily play the game that they were convenient with the level of difficulties and motoric levels. Comparing to the commercial games, they preferred SportWall game environment or game scene which is simple and appealing. The game feedback and scores displayed in the SportWall game were visible and clean enough so that they can easily understand their progress and performance. However, the elderly participants and the caregiver at the service home pointed out that some actions (e.g., Jump) in this game could lead the elderly to be fallen and elderly may become tired after some time. That is why, it is important to address some design issues in the Puuha's SportWall game that are not suitable for the elderly players. With regard to the multimodal input devices that we used in this study, we found out that the

elderly participants chose Xbox's motion-based Kinect sensor as the most effective device in playing game. In contrast, they claimed that PS3's PlayMove controller is the least effective in interacting with the game system because of its complications in pressing different buttons while they were playing. Therefore, it seems that controller-free interactive device is suitable for the elderly and their gameplay. However, it is important to conduct the usability study with larger sample size to be able to validate this finding. In general, the findings from our pilot user testing show that SportWall game is promising to be used for elderly's physical activity although there were some usability issues that need to be addressed. Figure 2 shows our pilot user testing with elderly participant. These preliminary findings are useful and insightful for our future design enhancement and development. Our future works includes the following:

1) To design and develop Kinect-based games that utilize the exercise library (e.g., Virtual swimming and Seated games)
2) To run the pilot test of these games with elderly patients
3) To re-design the current games by Puuha Game to be suitable for elderly player
4) To run the pilot test of Puuha Group games to investigate whether these games are elderly friendly
5) To run the pilot test of "Old Photos on Map Application" and to investigate its usability and usefulness
6) To decide how "Old Photos on Map Application" can fulfill the concept of social services in VNH system
7) To study the usability and usefulness the pilot test of "Top 100 Mountains game" and how it can be integrated into VNH system
8) To develop the ideas how we can adopt the motivational factors that we have found out in this literature review in our future game development and enhancement

Figure 2. A Pilot User Testing at Rääkkylä autumn 2014

7. Conclusion

We listed motivational factors of stroke patients' rehabilitation based on the literature. The factors are useful and insightful when designing digital games for stroke patients and their rehabilitation. We outlined game design considerations based on the motivational factors. Moreover, we have reported the four concepts: social services, rehabilitation services, entertainment services, and counseling services in our VNH system and how we can collaborate with partnered institutions. Currently, we are reviewing existing games from Puuha Group and developing new game concepts with Serious Games Finland. We have conducted our initial pilot user testing by using commercial games (Xbox's climbing game and PS3's tennis game) and non-commercial game (Puuha's SportWall game). The results showed that SportWall game has potential for elderly, but it is important to redesign to meet the needs of elderly. Moreover, the elderly participants claimed that they preferred the controller-free interactive device in the gameplay. Based on the findings from this pilot run, we will continue future enhancement and development followed by a larger usability testing with elderly at the service homes in Finland. Then, we will try to integrate the motivational factors that we reported in this paper into our new game design ideas in existing and new games.

Acknowledgements.

We would like to thank our collaborators and partners in the project called Gamified Solutions in Healthcare (GSH). This project was funded by Finnish Funding Agency for Technology and Innovation (Tekes), City of Turku, and several technological companies.

References

[1] Burke, J.W., McNeill, M.D.J., Charles, D.K., Morrow, P.J., Crosbie, J.H. and McDonough, S.M. (2010) Designing Engaging, Playable Games for Rehabilitation. In *Proceedings of International Conference Series On Disability, Virtual Reality And Associated Technologies (ICDVRAT)*.

[2] Chang, Y.J., Cheang, S.F. and Huang, J.D. (2011) A Kinect-Based System for Physical Rehabilitation. A Pilot Study for Young Adults with Motor Disabilities. *Research in Development Disabilities*, 32, 2566-2570.

[3] Maclean, N., Pound, P., Wolfe, C. and Rudd, A. (2002) The Concept of Patient Motivation: A Qualitative Analysis of Stroke Professionals' Attitudes. *Stroke*, 33, 444-448.

[4] Shen, Y., Ong, S.K. and Nee, A.Y.C. (2008) An Augmented Reality System for Hand Movement Rehabilitation. In *Proceedings of iCREATe'08*, 189-192.

[5] Halton, J. (2008) Virtual Rehabilitation with Video Games. A New Frontier for Occupational Therapy. *Occupational Therapy Now*, 9(6), 12-14.

[6] Anderson, F., Annett, M. and Bischof, W.F. (2010) Lean on Wii: Physical Rehabilitation With Virtual Retaily and Wii Peripherals. *Annual Review of CyberTherapy and Telemedicine*, 8, 181-184.

[7] Maclean, N., Pound, P., Wolfe, C. and Rudd, A. (2000) Qualitative Analysis of Stroke Patients' Motivation for Rehabilitation. *Bmj 2000*, 321 (7268), 1051-1054.
[8] Domboyy, M.L., Sandok, B.A., and Basford, J.R. (1986) Rehabilitation for Stroke: A Review. *Stroke*, 17, 363-369.
[9] Sanntus, G.A., Ranzenigo, A., Caregnato, R. and Maria, R.I. (1990) Social and Family Integration of Hemiplegic Elderly Patients 1 Year after Stroke. *Stroke 21*, 1019-1022.
[10] Recovery after Stroke: Social Support, www.stroke.org.
[11] Evans, R.L., Matlock, A-L., Bishop, D.S., Stranahan, S. and Pederson, C. (1988) Family Intervention After Stroke: Does Counselling or Education help?. *Stroke*, 19, 1243-1249.
[12] Shimoda, K. and Robinson, R.G. (1998) The Relationship between Social Impairment and Recovery from Stroke. *Psychiatry*, 61, 101-111.
[13] Finding Motivation after Stroke or Brain Damage, http://sueb.hubpages.com/hub/Finding-Motivation-after-Stroke-or-Brain-Damage.
[14] White, G.N., Cordato, D.J., O'Rourke, F., Mendis, R.L., Ghia, D. and Chang, D.K. (2012) Validation of the Stroke Rehabilitation Motivation Scale: A Pilot Study. *Asian J Gerontol Geriatr*, 7, 80-87.
[15] Flores, E., Tobon, G., Cavallaro, E., Cavallaro, F.I., Perry, J.C. and Keller, T. (2008) Improving Patient Motivation in Game Development for Motor Deficit Rehabilitation. In *Proceedings of Intl. Conf. on Adva.in Comp*. Entert, Tech., ACM, 381-384.
[16] Barry, J. (1965) Patient Motivation for Rehabilitation. *Cleft Palate J*., 2, 62-68.
[17] Krause, N., Frank, J.W., Dasinger, L.K., Sullivan, J.J. and Sinclair, S.J. (2001) Determinants of Duration of Disability and Return-to-work After Work-related Injury and Illness: Challenges for Future Research. *AMJ Industrial Med*, 40 (4), 464-84.
[18] Holmqvish, L.W. and Koch L. (2001) Environmental Factors in Stroke Rehabilitation, Being in Hospital itself Demotivates Patients. *British Medical Journal*, 322, 1501-02.
[19] Van-Vliet, P.M. and Wulf, G. (20016) Extrinsic Feedback for Motor Learning after Stroke: What is the Evidence?. *Disabil Rehabil*, 28: 831-40.
[20] Knight, A.J. and Wiese, N. (2011) Therapeutic Music and Nursing in Poststroke Rehabilitation. *Rehabilitation Nursing*, Vol. 36, No.5, 200-215. Leisure and Participation Information for Patients and Families, www.strokeengine.org .
[21] Roth, E.A. and Wisser, S. (2004) Music Therapy: The Rhythm of Recovery. *The Case Manager*, 15 (3), 52-56.
[22] Music Therapy, www.strokengine.ca.
[23] Lloyd, J. (2008) The State of Intergenerational Relations Today. ILC-UK .
[24] Theng, Y.L., Chua, P.H. and Pham, T.P. (2012) Wii as Entertainment and Socialization Aids for Mental and Social Health of Elderly. In *Proceedings of CHI'12 Extended Abstracts*, (New York: ACM), 691-702.
[25] Kenny, P., Parsons, T., Gratch, J. and Rizzo, A. (2008) Virtual Humans for Assisted Healthcare. In *Proceedings of 1st Int. Conf. on Pervasive Technology Related to Assistive Environments 1-4*, ACM Press, New York.
[26] Pyae, A., Tan, B.Y. and Gossage, M. (2013) Understanding Stroke Patients' Needs for Designing User-Centered Rehabilitative Games. In *Proceedings of The 7th Annual International Conference on Computer Games Multimedia and Allied Technologies*, 151-156.
[27] Mao, J.Y., Vredenbur, K. and Smith, P.W. (2001) User-centered Design Methods In Practice: A Survey of the State of the Art. In *Proceedings of Center for Advanced Studies on Collaborative Research*, 12.
[28] Boulet, G. Rapid Prototyping: An Efficient Way to Collaboratively Design and Develop E-Learning Content, http://www.guyboulet.net/site/docs/Rapid_prototyping.pdf.
[29] Malmivirta, H. Art as Bridge for Personal and Professional Growth. *Acta Universitatis Tamperensis 1629*. Tampere: Juvenes Print.
[30] Malmivirta, H. (2014) Yellow cottage and patch of potatoes. In Art and Culture – Keys for better Brain health. (ed.) H. Malmivirta & S. Kivelä. Turku University of Applied Sciences. Education materials 89. Turku University of Applied Sciences, 91– 26.