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Research Article

Opportunities of Markerless Motion Detection Systems for Use in Neurological Rehabilitation: A Qualitative Study on Patient and Therapist Perspective

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Abstract

Background: Markerless motion detection systems such as Microsoft Kinect are promising systems in client-centered task oriented training in central nervous disorders, but therapists and patients have specific expectations and requirements for use in rehabilitation. Therefore the aim of this study is to assess expectations and requirements of therapists and patients towards the use of Microsoft Kinect in neurological rehabilitation.

Methods: A qualitative design was used in which seven focus groups were performed with patients with neurological disorders (n = 15) and physio- and occupational therapists (n = 22) in four rehabilitation centres. The grounded theory was used to analyse data.

Results: Two main themes were identified: knowledge-use-experience and expectations and requirements. It was found that knowledge, use and experience cannot be separated as they are connected. Therefore, to use Microsoft Kinect in rehabilitation, people need knowledge and experience with the system. In order to be useful in rehabilitation, Microsoft Kinect system needs to be easy to use independently, easy to set up, low cost and small. The system should also provide patients and therapists with feedback of their performance and/or results.

Conclusions: As knowledge and experience with Microsoft Kinect are very important before and during first use, it seems important to inform therapists and patients about the advantages of Microsoft Kinect as opposed to robotic devices or marker-based motion detection systems. By integrating the expectations and requirements in future research, opportunities are created for using Microsoft Kinect into a new client-centered task oriented system in upper limb neurological rehabilitation.

Keywords: Motion detection system; Nervous system diseases; Rehabilitation; Qualitative research; Opportunities

Background

Central nervous system diseases such as stroke, multiple sclerosis (MS) and spinal cord injury cause serious impairment of the upper limb. The motor, sensory and cognitive impairments that occur in the upper limb, affect the performance of activities of daily life, sports and leisure activities. More specifically, they reduce functional independence and thus the quality of life of the individual.

Studies [1,2] have shown the importance of upper limb rehabilitation in the early stages after injury. Furthermore, these studies provided evidence that a task-oriented client-centered approach in upper limb rehabilitation is more beneficial than treatment as usual. However, a task-oriented client-centered approach needs more individualized therapy and is therefore more time consuming and costly for therapists and rehabilitation centres. Hence a new approach is needed to be able to administer task-oriented client-centered therapy in neurological rehabilitation without extra costs and therapists.

Technology-based systems, such as robotics and motion detection systems, are promising. Robotics have gained acknowledgement as it is indicated that robotic therapy can improve long term effects on motor-control aspects (e.g. muscle activation patterns) [3]. But robotics is also very expensive, is often complex in set up and need more space. Also, users need specific knowledge and/or skills to be able to work with the robotic device. Motion detection systems might counteract the disadvantages reported in robotics [4,5].

Motion detection systems have been used for some time. The traditional marker-based system, that is considered as the gold-standard and known as VICON, is predominantly laboratory based. For this system, the therapist needs detailed knowledge of anatomy, knowledge of how the system works and experience with the system. On the other hand there are Markerless systems, such as the Microsoft Kinect sensor for use with Xbox360. This system can be used immediately after setup, without specific knowledge or skills. Studies have demonstrated good level of agreement between VICON and Microsoft Kinect with regards to valid assessment of postural

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control movements and reproducibility of functional assessment in upper and lower limb [4,5,6].

Although Markerless motion detection systems such as Microsoft Kinect have a lot to offer in rehabilitation settings, adapted applications regarding the usefulness of these systems in upper limb neurological rehabilitation are scarce, as well as research. To gain insight into the opportunities of the Microsoft Kinect in upper limb neurological rehabilitation, the expectations and requirements of the Microsoft Kinect according to the users in neurological rehabilitation need to be known. Therefore the aim of this study is to assess the expectations and requirements of Microsoft Kinect according to users, patients as well as therapists, to be used in rehabilitation. These expectations and requirements will be taken into account for further development of the system within neurological task-oriented and client-centered upper limb rehabilitation.

Methods

A qualitative design was used to analyse data obtained from a series of focus groups in which semi-structured interviews were performed with 1) patients with neurological disorders and 2) occupational- and physiotherapists in four different rehabilitation centres. Participants were asked questions with regards to general use of technology in daily life, use of technology in rehabilitation setting and use of Microsoft Kinect in rehabilitation. In order to familiarize participants with the Microsoft Kinect, a demonstration was shown with self-made examples, during the focus groups. All focus groups were audio-recorded and led by the same moderator.

Patients were included when diagnosed with multiple sclerosis, stroke or spinal cord injury. Therapists had at least two years of experience in neurological rehabilitation. For each group (i.e. patients versus therapists) a separate, but similar interview guide was made. Approval of the appropriate ethical committees was fulfilled and informed consent was obtained from all interviewed subjects before participation.

Qualitative data analysis was conducted using grounded theory [7]. The audio recordings of the semi-structured interviews of the focus groups were transcribed ad verbatim before coding was performed. Open coding on the transcripts followed the structure of the focus group and interview guides. Axial coding was applied, on themes arising from the open coding. Then a comprehensive thematic analysis scheme was prepared (selective coding) before reviewing the scheme and cross-checking the findings against the original transcripts to confirm the findings.

Results

Firstly, a short representation of the characteristics of participants will be given. Then the main results will be presented regarding the two main themes that were identified after coding: 1) the triangle of knowledge-use-experience and 2) expectations and requirements of the markerless motion detection system Microsoft Kinect (Figure 1).

Participants characteristics

A total of 15 patients and 22 therapists participated in seven focus group sessions over four different institutions. Characteristics of the sample are presented in Table 1.

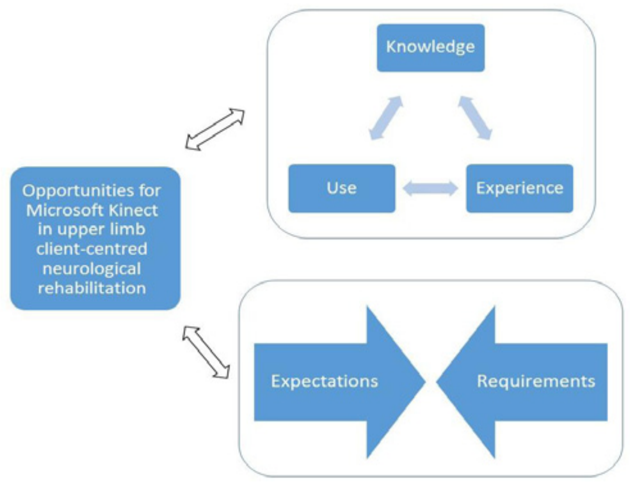

Figure 1: Representation of main criteria of findings.

Table 1: Characteristics of participants.

	Patients	Stroke/MS/ SC/ Other	Therapists (OT/PT)	Total (n)
Herk-de-Stad (n)	5	4/0/0/1	3/3	11
Overpelt (n)	4	0/4/0/0	3/3	10
Lanaken (n)	6	4/0/2/0	3/2	11
Melsbroek (n)	0	0/0/0/0	5/0	5
Total (n)	15	8/4/2/1	14/8	37

MS: Multiple Sclerosis; SC: Spinal Cord; OT: Occupational Therapist; PT: Physiotherapist/

Knowledge-Use-Experience of markerless motion detection systems

The terms knowledge, use and experience cannot be seen separately as the level of knowledge of technology depends on whether a person has used technology before and thus has experience with technology. Some participants even formulated this statement during the interview:

"Yes, as a therapist you have to know beforehand how it all works. The therapists and patients that know the technology from own experiences, are probably more inclined to use the technology earlier and more than others." (Therapist 1)

"And as a therapist you have to know what you are doing, which buttons to push and so…. I think that once you tried it with a patient and all goes well, you will use it more often." (Therapist 2)

"It (technology) can go very far (in complexity). I'm not sure whether complex technology is still easy to use. (…) It's like a cell phone: it can do a lot. But for me it's not so easy to use although I use it every day for calls and text messages." (Patient 1)

It was remarkable that one institution did not use any technology at all during therapy. All therapists of this rehabilitation centre had negative comments about the use and purpose of technology in neurological rehabilitation. In contrast, the other three centres did use technology such as Nintendo Wii, You Grabber, even Microsoft Kinect (as commercially available), etc. during therapy. All therapists as well as patients of these centres had experience and/or knowledge of some technological systems in upper limb neurological rehabilitation. Also, even when no technology was available in the rehabilitation centre and technology was not presented during therapy, patients would like to use technology in rehabilitation because they were interested and had knowledge of technology before starting their rehabilitation. One patient of the centre that did not use any technology during therapy stated that he would like to use technology as he is convinced of the benefits due to personal interest and use in daily life.

When asked about specific technology in rehabilitation, most patients knew about the Nintendo's Wii, but never used it. Patients that did use Nintendo's Wii, did not use it in the rehabilitation setting. Alternatively, there are therapists that have used Nintendo's Wii in rehabilitation and see the advantages of game related therapy:

"The Wii gets people motivated to move who don't want to do analytical exercises." (Therapist 3)

"With the Wii, people can play against each other." (Therapist 4)

"The Wii connects older people with their kids or grandkids." (Therapist 5)

When asked about the use of the Microsoft Kinect, different answers were apparent depending on the experience. Therapists who were not familiar with technology in rehabilitation expressed that they did not want to use technology, including the Microsoft Kinect, because it cannot register detailed movement as good as a therapist. Furthermore these therapists could not see the advantage of using the Microsoft Kinect in an additional therapy or therapy at home as this was not their way of working. These therapists stated that all exercises should be done in the rehabilitation center under supervision of a therapist and no homework should be given, so patients should not exercise in their home setting.

The therapists who were familiar with technology in rehabilitation settings, stated that the Microsoft Kinect could be used for patients that are motivated and interested in technology, and specific goals could be set for these patients. In this group of patients, therapists should not encounter major difficulties to push people to exercise with the Microsoft Kinect as additional therapy, or even to exercise at home.

Expectations and requirements of the markerless motion detection system Microsoft Kinect

Most participants, especially the therapists who had experience with technology and/or Microsoft Kinect, could see advantages of the Microsoft Kinect system in upper limb neurological rehabilitation. Especially because there is no need for a controller or placing sensors on the patient's body.

Furthermore, therapists stated that they can treat more than one patient at a time and the use of technology might be an additional motivation and/or make the therapy less boring because of the endless variety of exercises and activities. The latter also being expressed by some patients. However the motivation of the patient seems essential: when patients are not motivated or have no interest in using technology, it is not worth trying.

For patients, the main advantage of the Microsoft Kinect would be the possibility of using this as an additional therapy without assistance of therapists, and even to exercise at home. Furthermore, if patients could use this system at home, an additional advantage is that they would need less transportation between home and rehabilitation centre. Hence the statement of some patients that the further people live from the rehabilitation centre, the more they are willing to try technology such as the Microsoft Kinect, under condition that therapists can follow their progress.

Therapists discussed their expectations concerning the registration of the results. For therapists, the results should be clear and short, and mainly given directly after the exercise. The focus on feedback of results was different for all four rehabilitation centres. In one centre, therapists would focus on the way patients perform movements (knowledge of performance), with force and speed as important outcome measures. In another centre, therapists found it extremely important to register compensational movements in the shoulder. Therapists of the third rehabilitation centre found the result (knowledge of result) more important than the way a patient moves. In this centre, the registration of compensational movement would be an added value for the therapist. In the last center, therapists focus on knowledge of result, but would also like to have results with regards to timing, coordination and the onset of the movement. The latter group of therapists remarked that this difference of focus could depend on the diseases: in people with stroke, therapists would focus more on regaining a good performance during movement, while in people with more degenerative diseases, such as MS, therapists would focus more on the result.

Patients were more unanimous concerning their expectations with regard to feedback; they report that it is important for them to receive feedback regarding the movement itself and not so much the result of the movement. So knowledge of performance is more important for the patients than knowledge of result.

Most participants, patients as well as therapists, expect the type of feedback to be adjustable for every single user: visual, audible and/or tactile feedback. It was suggested to work with the 'green is good and red is wrong' principle.

Concerning the visual characteristics of the Microsoft Kinect interface, all participants expressed their preference of an avatar with humanly features and the use of a plane background interface (i.e. not too busy with too many colours, not too many shapes in the background, etc.). The latter because otherwise the attention would be on the background or side information instead of the exercise itself.

To be able to use the Microsoft Kinect, therapists and patients expressed that some basic requirements need to be fulfilled, such as user-friendly interface, not time consuming regarding set up of the system, and the apparatus should be small instead of taking up too much space.

The most important requirements therapists expressed about the use of technology and Microsoft Kinect in particular in rehabilitation, was that the system should be low cost and easy to use (independently). All therapists with experience in technology stated that most technology is very expensive and that the rehabilitation centre cannot afford this. Especially if the system needs regular updating or additional software over time. Furthermore, most technological systems are so complex that it takes too much time to get to know the technology, how to set it up and how it works.

For patients the main requirement would be to keep contact with the therapists and feedback possibility from therapist to patient. Patients emphasized the importance of a good relation and social interaction with their therapist, and knowing that their therapist(s) can follow up their progress.

Discussion

It seems to be crucial that therapists have knowledge or some experience with Microsoft Kinect before using it in training. With regards to the expectations and requirements, participants expressed their preference regarding feedback and visual characteristics. Furthermore, participants want a user-friendly interface that is easy to use (independently), an apparatus that is not time consuming to set up, small and affordable.

The differences between the therapists of the four specialized centres and their knowledge-use-experience of technology and Microsoft Kinect specifically, were noticeable during the focus groups and obvious during the analyses. The therapists with no or very limited knowledge and/or experience with technology during therapy session, were more reluctant towards using the Microsoft Kinect in upper limb neurological rehabilitation. Also, these therapists could not report possible advantages of using technology-based training as an additional therapy in neurological rehabilitation. In contrast, therapists with knowledge and/or experience with technology were quite positive about using technology and more specifically the Microsoft Kinect in their therapy. Therefore, to make therapists less reluctant towards using technology such as Microsoft Kinect in their therapy, informing these therapists of the advantages and provide training in using technology in rehabilitation might break the negative triangle of knowledge-use-experience. It is shown that systematic active information, training and community support for patients and carers improves satisfaction with rehabilitation programs [8].

The expectations and requirements expressed by patients and therapists can be linked to the advantages of the Microsoft Kinect as opposed to robotics [4,5]. The Microsoft Kinect is a commercially available, small motion detection system that uses cameras with no need for a controller or body-worn sensors. Therefore it is easier to set up and use than most robotic devices. In rehabilitation, therapists could be able to treat more than one patient at a time, while patients stay motivated as there is an endless variety in exercises and activities. Furthermore, these advantages could make it possible for patients to use the Microsoft Kinect at home as well.

The reported expectations and requirements are feasible to integrate in the final system with Microsoft Kinect. Furthermore, integrating these expectations and requirements, together with the advantages of the Microsoft Kinect in relation to robotics, creates great opportunities for the use of the Microsoft Kinect in client-centered task oriented therapy in upper limb neurological rehabilitation.

Another finding was the different focus on feedback of results. This was different for all four rehabilitation centres. Although the focus was different, it can be stated that three out of the four centres focuses on knowledge of performance and one centre focuses on knowledge of result. Although the latter group of therapists remarked that this could be related to the main target group of the rehabilitation centre (i.e. either MS where focus is on knowledge of results or stroke where focus is on knowledge of performance), this remark cannot be funded by literature [9,10]. In stroke, it is suggested that feedback in the form of knowledge of performance may lead to better recovery of list motor patterns than knowledge of results [9]. In MS, no research was found that described the best usable form of feedback during or after motor training [10].

Some methodological considerations can be made. The focus groups took place in four specialised neurological rehabilitation centres in Flanders (Belgium) with only 15 patients and 22 therapists participating in which multiple disabilities and functions were enrolled. On the one hand, this is an advantage as many different opinions were gathered and could be included in the development of the system, which is aimed to be used in clients with different neurological disorders. An even larger sample size of patients with neurological diseases and therapists could expose even more requirements and expectations. On the other hand, generalising the data beyond these institutions should be done with caution.

Furthermore, the moderator was also part of the team of analysts; hence a bias in the analyses cannot be excluded. However, all analysts came to a consensus during all phases of the grounded theory and new themes did not emerge when nearing the termination of the coding and interpretation. Therefore it is unlikely there are additional major themes to be acknowledged within this research.

The strength of this study lies in identifying the expectations and requirements of patients and therapists with regards to using the Microsoft Kinect system in rehabilitation, and taking these findings into account during the development of a Kinect-based system for use in client-centered task oriented neurological rehabilitation.

Conclusion

Study findings suggest that knowledge, experience and use are linked with each other. To stimulate the use of technology, and more specifically the Microsoft Kinect, in neurological rehabilitation, therapists need to be informed about the advantages of the Microsoft Kinect as opposed to robotics or marker-based systems, and provided with training.

Participants expressed that the Kinect-based system, should mainly provide feedback on the movement itself (knowledge of performance).Patients and therapists require that the Kinect-based system, should be easy to use independently, with simple background colours and/or scenes, and a clear representation of a human being. The basic system, as well as the possible updates or additional software should also be affordable. To be used at home by patients, patients as well as therapists indicated the importance of user-friendliness (i.e. small, easy to use and set up) and the ability to follow up the progress of the patients. These expectations and requirements expressed by patients and therapists are feasible to integrate into the development of a Kinect-based system. This creates great opportunities for the Microsoft Kinect for use in client-centered task oriented upper limb neurological rehabilitation.

Based on these results, the software of Microsoft Kinect will be further developed and integrated into a client-centered task oriented rehabilitation system, taking into account the expectations and requirements on different aspects and properties from all users, i.e. patients as well therapists. During this process, more interviews, demonstrations and also feasibility and pilot studies will be executed by means of an iterative process, in neurological rehabilitation settings with the modified system of Microsoft Kinect to enhance the final system for use in client-centered task oriented therapy in upper limb neurological rehabilitation.

Authors' Contributions

EK and AS conceived of the study, participated in its design and coordination, and drafted the manuscript. EK performed data collection, qualitative analysis and interpretation. AS provided project management and consultation. All authors read and approved the final manuscript.

Author's Information

EK (MSc) is lecturer and researcher at PXL University College Hasselt. She studied Occupational Therapy and graduated as a Master of Science in Physical Activity and Health. She has experience with research in assistive technology and robotics in neurological rehabilitation. As a research assistant she was involved in the first three years of the iTravle project (INTERREG IV "Rehabilitation Robotics II", code IVA-VLANED-1.14). Currently, she is working at the Department of Healthcare – Research at PXL University College Hasselt under supervision of Dr. Annemie Spooren.

AS (Dr) is research coordinator of Healthcare – Research at PXL University College Hasselt and lecturer at Hasselt University in Master of Occupational Science. She finished her PhD in rehabilitation sciences in 2010 (at VUB (Brussels Belgium and funded by the PXL University College)) on client-centered task-oriented rehabilitation. She was related to Maastricht University and Adelante Centre of Expertise (Hoensbroek, NL) as a post-doc and is currently involved in various research projects regarding client–centered task-oriented training, innovative rehabilitation processes and the use of technology-assisted training of the upper extremity in persons with neurological disorders for which she obtained several national and international funding.

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