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Choice of an outcome measure for Virtual Reality motor training in acute neurorehabilitation.

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Abstract:	Background: the occurrence of new stroke cases is estimated at 15 million worldwide every year representing the second leading cause of death worldwide during a given ten year period. 75% of stroke survivors suffer from upper limb paresis: studies suggest that only 50% of patients with significant arm paresis recover useful function, so it is crucial to find new techniques of rehabilitation and high-performance outcome measurements tools. Virtual Reality (VR) represents a valuable technology for training the cognitive and motor functions of stroke patients. Successful rehabilitation requires a valid and reliable assessment methodology for tracking the therapy progress. Methods and Results: We first made an analysis of movements offered by the MindMotionPRO VR motor rehabilitation platform. Then a literature review of outcome measurement tools was carried out in order to correlate the selected tools to this platform. Among the investigated motricity and motor function outcome measures, we found that the Fugl-Meyer scale (FM) is the most appropriate, evaluation by its tested movements and its good validity, sensitivity, responsiveness, reliability and its good correlation with ADL in accordance with MindMotionPRO motor rehabilitation exercises. Discussion: The movement analysis of the VR platform is well suited to neurorehabilitation in the acute phase. After a literature review, the FM scale was chosen as an adequate evaluation scale of the movements trained by the VR platform. Conclusions: We recommend using the FM scale to evaluate the outcome of training with this VR platform. Further studies are planned to show the effectiveness of this training also in the post-acute phase.
Keywords:	Virtual Reality; post-stroke; outcome measurement; Neurorehabilitation; acute care unit; Frenchay arm test; Wolf Motor Function Test (WMFT); Fugl-Meyer; upper limb
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Choice of an outcome measure for Virtual Reality motor training in acute neurorehabilitation.

Choice of an outcome measure for Virtual Reality motor training in acute neurorehabilitation.

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Abstract

Background: the occurrence of new stroke cases is estimated at 15 million worldwide every year representing the second leading cause of death worldwide during a given ten year period. 75% of stroke survivors suffer from upper limb paresis: studies suggest that only 50% of patients with significant arm paresis recover useful function, so it is crucial to find new techniques of rehabilitation and high-performance outcome measurements tools. Virtual Reality (VR) represents a valuable technology for training the cognitive and motor functions of stroke patients. Successful rehabilitation requires a valid and reliable assessment methodology for tracking the therapy progress.

Methods and Results: We first made an analysis of movements offered by the MindMotionPRO VR motor rehabilitation platform. Then a literature review of outcome measurement tools was carried out in order to correlate the selected tools to this platform. Among the investigated motricity and motor function outcome measures, we found that the Fugl-Meyer scale (FM) is the most appropriate, evaluation by its tested movements and its good validity, sensitivity, responsiveness, reliability and its good correlation with ADL in accordance with MindMotionPRO motor rehabilitation exercises.

Discussion: The movement analysis of the VR platform is well suited to neurorehabilitation in the acute phase. After a literature review, the FM scale was chosen as an adequate evaluation scale of the movements trained by the VR platform.

Conclusions: We recommend using the FM scale to evaluate the outcome of training with this VR platform. Further studies are planned to show the effectiveness of this training also in the post-acute phase.

Introduction

The World Health Organization (WHO) estimates the occurrence of 15 million new stroke cases worldwide every year. In 2012, the WHO reported 6.7 million stroke-related deaths occurring between 2000 and 2012, representing the second leading cause of death worldwide during the ten-year period[1].

Strokes can cause a wide range of neurological impairments, which severely reduce a patient's ability to perform activities of daily life (ADL). Seventy-five percent of stroke survivors suffer from upper limb paresis, which can have a particularly severe impact on ADL, therefore limiting independent living. The arm function is especially important in regaining autonomy. Longitudinal studies of recovery after stroke suggest that only 50% of patients with significant arm paresis recover useful function. Initial severity of paresis remains the best predictor of recovery of arm function.[2]

The ability to recover, measured as the change in Functional Independence Measure (FIM), is highest during the acute phase, in particular within the first 15 days after stroke[3 4]. However, due to early post-stroke medical complications and other clinical factors, the average time from stroke onset to upper extremity rehabilitation and assessment admission interval is 17 days[5]. It has been widely advocated that early intervention directly in the acute phase (2-4 days post-stroke) to exploit the unique neuroplasticity conditions and with intensive motor training are highly desirable for the survivor's improved recovery[6]. As the acute-care units and acute rehabilitation units are not always equipped to deliver the level of intensity required, the lack of personal resources can be completed by training by robotic devices. However, the feasibility of this type of training and the evaluation of the impact on outcome is still poorly documented. Recently, virtual reality (VR) applications have emerged in the rehabilitation landscape[9]. VR refers to a computer-generated technology that creates immersive, interactive scenarios surrounding the participant. VR-based therapy solutions are indeed a powerful medium to fill this gap. VR-based neurorehabilitation can be gamified to intensify training[7] and additionally they can be easy to setup and require less labor[8]. Moreover, VR enables flexible and customizable manipulations and feedback modes which can be matched to the physical and cognitive impairments of each patient[9]. For example, when the survivor's paretic side is highly impaired (mostly the case in the acute phase), the VR-based exercises that integrate evidence-based medicine in the neurorehabilitation (e.g., techniques that rely on the brain's mirror system via action observation, guided imagery etc.) can help the survivor to pre-activate neural structures involved in motor recovery. Early intervention and coupling with objective measures for monitoring the patient's progress are attractive features of VR in Upper Extremity Assessment[10]. The capacity of VR-based systems as a facilitation tool for testing functional recovery and engaging brain circuits[11], such as motor areas, has been demonstrated.[12] In a Cochrane review comprising 37 studies involving a total of 1019 post-stroke participants, VR-based therapy was found to be significantly more effective than conventional therapy in improving the upper limb function[13]. Such successful upper extremity rehabilitation may require accurate and effective assessment of the effectiveness of training.

The VR-based motor rehabilitation system that we refer to in this paper is called MindMotionPRO (MindMaze SA). It offers exercises that encourage movements in the air to enable functional movements such as grasping, reaching for a target, or pointing to a virtual object in the air and can be applied to the patient in an acute rehabilitation unit either at the bedside or in a wheelchair according to patient's abilities. These exercises engage the patient's shoulder, elbow, forearm and wrist movements. Hence for tracking the patient's upper extremity motor performance the assessment questionnaire chosen must reflect these training components to ensure sensitivity. The challenge here is that the chosen motor assessment must also not be time-consuming be able to use the early recovery period in acute care units. In addition, many of the traditional methods of assessing brain-injured individuals use either basic pencil and paper techniques or simple motor tasks[14]. In cases of upper extremity impairment, the patient is asked to indicate specific symbols, draw a straight line or reach and place objects as accurately and as quickly as possible[15]. One common criticism of these tests is that the patient is not being tested in a practical ADL systematic way. However, it has been demonstrated that an improvement in the Fugl-Meyer scale (FMS), in the Barthel Index (BI), or in the Functional Independence Measure (FIM) is significantly correlated with an increase in ADL. Nevertheless, FIM and BI are less suitable than VR because they do not measure the dynamic process of motor recovery nor do they assess movements trained on the platform.[16] A numbers of studies have emphasized the requirement for rehabilitation testing methods that are relevant to the patient's real world environment and which can be transferred to other daily tasks of living.

MindMotionPRO Virtual Reality in acute motor training

The system is a mobile platform (fig.1) that exploits immersive VR for assessing an upper limb for people recovering from stroke or brain injury. It uses enhanced kinematic motion detection to create an immersive virtual environment in which a person can have custom-designed sets of activities and games that simultaneously stimulate, challenge and motivate.

The platform consists of a motion capture system that tracks the upper extremity and a screen displaying an avatar in a 3D virtual environment from an elevated first-person perspective (fig.2). The movements of the patient's upper extremity are tracked by a camera and mapped in real time to the avatar displayed on the screen.

The patients can perform different tasks using one arm (unimanual task). In these exercises the patient has to: reach appearing targets in the virtual environment following a linear path, point to a target, grasp a target and bring it into a predefined area, or to cut some fruits (fig.2).

From each task performed, we computed three measures from the 3D motion tracking data (duration, reaction time and accuracy). A reduction in task duration, a reduction in time reaction and an increase in accuracy indicates the patient's learning capacity of the task showing clear patterns of progress in their training.

In addition to the MindMotionPRO interface, mirror mapping is an additional tool (fig.3) which can be added to every trained motion on the platform. In neurorehabilitation, it has been proven that mirror therapy produces better outcomes in comparison with classical therapy[17].

With respect to the advantages of motion data tracking in comparison to conventional assessments, one can use data such as the patient's and therapist's feedback to indicate a patient's workout summary as well as an objective assessment of range-of-motion. Such feedback to the patient could motivate and aid them in achieving functional improvement.

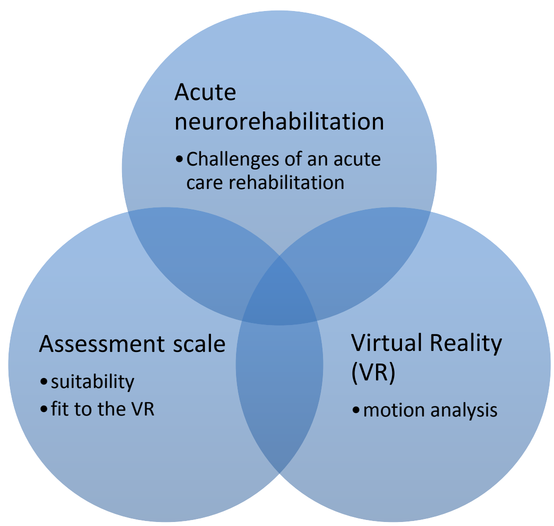
We would like to integrate VR in conventional stroke rehabilitation which is adapted to the conditions and the environment of an acute ward for an unstable stroke patient with cerebral reorganization. The platform must adhere to the following conditions during an investigation/evaluation:

- Real-time multisensory feedback, especially visual feedback during movement execution.
- Stimulation of a complete plegic arm without confrontation of the patient's incapacity.
- Adaption of VR hardware, which can be integrated into an existing environment (i.e. patient's room) and requires minimal personal resources.
- Training of the movements, which correspond to the patient's deficit and are in alignment with his individual goals.
- Measurement of this individual training program by adapting skill.

Methodology

As we can find in the Venn diagram, in this fallowing section we tried to identify current difficulties in acute care neurorehabilitation, to verify if the MindMotionPRO platform could be applied in an acute phase of rehabilitation, then we searched for a reliable assessment scale matching with VR motion but also suitable for the acute phase.

Fig.5: Venn diagram integrating the 3 domains:



Acute rehabilitation intervention and needs:

The major issue in the acute phase remains that the patients are very impaired, whether on the motor side or on the cognitive side, so it is required that the tools of rehabilitation suit this kind of patient. They must be physically practical, for example usable at the bedside, but also that utilized exercises are simple and can be shaped to the difficulties of the patient.

In the domain of stroke, there is a vast choice of interventions for motor recovery of patients. They have all proven their efficiency and are commonly used in rehabilitation centers. For the upper limb, the best known are: motor learning, a neuropsychological approach, with essentially the Bobath system, constrain induced movement therapy, repetitive task training, high-intensity therapy, electrostimulation; mental practice with motor imagery, robotics: a robotic device allows the patient to repeat a specific task with or without a small intervention by a therapist and virtual reality[18].

As mentioned above, all these therapies have already proven their effectiveness and are therefore commonly used in acute rehabilitation centers. However, it would be interesting to integrate several types of approaches with one instrument. With a technical platform, it is possible to mix these different therapies to get the best of them (i.e. motor learning, constrain induced movements, repetitive task training, high-intensity therapy). Besides, we could integrate a biofeedback to the rehabilitation.

The tools currently used to assess patient's improvement are Nine Hole Peg test, Frenchay arm test, Barthel index, FIM and Action Research Arm Test[19]. These scales are very necessary for clinical practice but they are often too inaccurate, evaluating tasks rather than the trained motor function directly.

MindMotionPRO motor training components:

We could describe in a more detailed manner the movements tested during exercises on MindMotionPRO device, which are grasping, reaching or pointing, if we dissect these movements into several stages according to the joints of the upper limb, so we have: shoulder: abduction, adduction, flexion, extension internal and external rotation; elbow: extension and flexion; and wrist palmar flexion, dorsiflexion, radial and ulnar deviation, as shown in the table below (table 1).

Literature review of outcome measures:

To access the outcomes of post-stroke patients, it is essential to have the most appropriate measurement scale for assessing the trained exercises on the VR platform. As part of the initial assessment process, a literature search was performed.

A literature search was performed using the PubMed and ScienceDirect databases, which included a date range of literature published from 1987 to October 2015. The purpose of the literature search was to become familiar with the existing literature covering the subject of rehabilitation using VR and to identify the appropriate scale for the outcome measurement.

In order to compare outcomes of classical therapies or VR therapy for hemiparetic patients after stroke, it is compulsory to have a specific measurement scale which fits with what we are training. In neurorehabilitation we have a lot of outcomes measurement tools; here we discuss three scales commonly used in rehabilitation centers.

The Frenchay arm test is a specific upper limb test, which assesses the ability to perform a specific task with the paretic limb. Five tasks are rated (1 point when the task is performed completely and 0 points when the patient fails); the total score has a maximum of 5 points. This test has the advantage of being a quick test: when you are a qualified examiner it takes less than 3 minutes to perform it.[20] This test was not chosen as it does not evaluate the specific movement trained by the platform.

The Fugl-Meyer is one of the most used scales in neurorehabilitation and is also a very comprehensive test.[21] We discuss only the part for the upper limb of the FM scale. This part is made-upof 33 domains with a maximum score of 66 points. These domains measure motions of the shoulder, elbow, forearm, wrist, hand, fingers, and grasping. The patients are rated on a scale from 0 points (no active movement) to 2 points (normal movement) for each domain.[16, 21]

The Wolf Motor Function Test (WMFT) quantifies the upper limb movement using timed tasks and functional exercises. In total, 15 timed tasks and 2 strength tasks are used. Exercises 1 to 6 evaluate the shoulder and the elbow, tasks 7 and 14 evaluate strength and the other remaining tasks evaluate the arm and the hand with variations in the complexity[22]. WMFT is a commonly used test, with a good reliability between interraters, with good specificity and validity.

After having identified the main difficulties of neurorehabilitation of the upper limb in the acute phase, analyzed in detail the movements trained on the platform, and reviewed literature focused on the 3 outcome measurement tools, we compared these different scales in order to determine the most appropriate evaluation tool to train the upper limb by this VR platform in an acute neurorehabilitation care unit.

Results

After examination of the review of literature, 3 outcome evaluation scales were highlighted; these tools were widely present in the literature.

The comparison of these 3 outcome measurement tools were summarized into 2 tables (table 2 and table 3). Table 2 compares advantages and disadvantages of the evaluated movements and tasks, verifying if the movements were evaluated simultaneously (in synergy). Table 3 compares the evaluated task and the trained movements induced by this task of these 3 scales.

This comparison permitted to analyze that all the tasks and trained movements by the platform are tested with the WMFT or with the FM upper limb scale. The FM scale analyzed in a more breaking-down manner the motions of the upper limb, especially wrist movements with specific domains for it, whereas the WMFT integrated wrist movements in tasks such as stacking pawns, returning cards or turning a key in a lock instead of having precise motion domains. The WMFT gives a detailed analysis of the movements. Nevertheless, we chose the Fugl-Meyer upper limb scale as it evaluates specifically the movements trained by the platform allowing for the monitoring of the evolution of the trained motor pattern (velocity, acceleration or time reaction).

An important part of neurorehabilitation is to improve the ADL score of patients as the capacity to perform ADL determines autonomy, one of the main conditions to return back to home. Therefore, the assessment scale should also make it possible to establish a good correlation with ADL improvement. The FM scale has a good correlation (0.75 of correlation coefficient) with ADL score; providing a good validity to measure the improvement of the patient's recovery after stroke. [16]

Moreover, the FM scale has a great level of responsiveness: when we have an increase in the score, it is that we have a clinical improvement. The FM scale has been correlated with the Functional Independence Measure (FIM). We can see an increase in both scales: when we have a 24 points increase in the FIM, we have a 10-point increase in the FM scale. As a result, improvement in motor function is associated with a significant functional recovery (E. Black et al.)[16].

In addition, the test has shown a good reliability between rated patients, but also when we are changing the rater therapist for the same patient.[16]

Discussion

The evaluation of the feasibility of the VR platform showed that it can be easily used in the acute phase of neurorehabilitation, especially as it can be brought directly to the bedside of the patient. Furthermore, the exercises which it proposes adapt themselves easily to the deficit of the patients; although the platform presents basic motions, they have already proved their efficiency for a long time.

The review of literature identified three scales to be the most appropriated to fulfill the challenges of neurorehabilitation during the very acute phase by virtual reality. Finally the detailed comparison of these three tests concerning the task-specific movement trained by the platform permits to argument the choice of FM as the proposed assessment scale to evaluate the effect of VR training by MindMotionPRO Virtual Reality. The excellent quality of this test, its good validity, sensitivity, responsiveness, reliability and its good correlation with ADL, have already been known for a long time. However, little research has confronted the VR and this scale.

Furthermore, this scale, by its relatively simple and basic motion assessment, can easily adapt itself to an interpretation in an acute phase with very impaired patients. One of the only current constraints would be the time which it takes to be realized and could not be used necessarily daily in clinical neurorehabilitation.

In summary, we can say that the FM scale suits the VR platform very well corresponding to the conditions of an appropriate program of neurorehabilitation of the upper limb during the very acute phase.

A further study has been started to validate the pertinence of the choice of the assessment scale in correlating the kinematic measurement tool integrated in the platform and correlation of the ADL measurement.

Conclusion

VR in medical applications, and especially in neurorehabilitation, is expanding really fast. It is important to have a very good platform, which is easy to use for the patient and also the therapist. We know that patients need something that entertains, stimulates, and challenges them to have good and fast improvement; all those skills are totally achievable with the MindMotionPRO platform.

The MindMotionPRO platform for the moment is still in the trial phase, but the analysis of feasibility showed that it can be included in neurorehabilitation of the upper limb of patients in the acute and post-acute phases of stroke. Accordingly, we need an efficient tool in order to evaluate the patient’s motor recovery with the most accurate method..

In conclusion, we can say that VR has the potential of providing new assessment scales, with precise measures of velocity and/or reaction time; as well as the ability to give a more precise shaping of therapy, with personalized exercises and goals for each patient, which can be adapted in function of previous measures of motion (velocity, acceleration, stability).

Tables:

Table 1: MindMotionPRO exercises description and primary movements;

<table>
<tr><th rowspan="2">Exercises</th><th rowspan="2">Rehabilitation activity</th><th colspan="7">Primary movements (X: used, and N: non-used)</th></tr>
<tr><th>Shoulder Flexion</th><th>Shoulder Abd-Adduction</th><th>Shoulder Int- Ext. Rotation</th><th>Elbow Flexion</th><th>Elbow Extension</th><th>Wrist palmar flexion, dorsiflexion</th><th>radial and ulnar deviation</th></tr>
<tr><td>Reach</td><td rowspan="2">Reaching from midline start pad to targets distributed across table height</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>N</td><td>N</td></tr>
<tr><td>Reach-Hand</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>N</td><td>N</td></tr>
<tr><td>Grasp</td><td rowspan="2">Reaching from midline start pad to elevated disc and then placing disc on targets distributed across table height</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>N</td><td>N</td></tr>
<tr><td>Grasp-Hand</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>N</td><td>X</td></tr>
<tr><td>Point</td><td rowspan="2">Pointing from midline start pad to elevated targets distributed across shoulder height</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>N</td><td>N</td></tr>
<tr><td>Point-Hand</td><td>N</td><td>X</td><td>X</td><td>N</td><td>N</td><td>X</td><td>X</td></tr>
<tr><td>FruitChamp</td><td>Point-hand game in an evolved environment</td><td>X</td><td>X</td><td>X</td><td>X</td><td>X</td><td>N</td><td>X</td></tr>
</table>

Table 2: Comparative of the 3 outcome measurement tools:

Scales	tasks performed	Synergy	Advantages	Disadvantages
Frenchay arm test	Stabilize a ruler, draw a straight line, grasp a cylinder and lift it, comb his hair, drink a glass of water, and open a cloth peg.	There are no exercise permitting to evaluate an isolated movement. The movements are evaluated in the form of tasks.	It can be done quickly (approx. 3 min). It shows a good validity.	It evaluates tasks but not specific movements. The scale has a maximum of 5 points, and rating is pass or fail, by giving 0 or 1 point to each task. It demonstrates a limited sensitivity.
Fugl-Meyer upper limb	Shoulder: abduction, adduction, elevation, retraction pro/supination. Elbow: flexion, extension. Forearm: pro/supination. Wrist: flexion extension. Hand: grasp, flexion and extension of mass fingers.	The movements are measured in synergy with exercises evaluating a movement (such as flexor synergy item), but also with targeted exercises.	Made of 33 domains to be more precise. Rating by 0,1 or 2 each task with a maximum score of 66 points. It has a good validity, sensitivity, responsiveness and reliability. We have a good correlation between ADL and Fugl-Meyer scale.	Take some time to be done, approximately 25 minutes. Due to its complexity, it requires a trained therapist.

Wolf Motor Function Test	Put forearms on the table (laterally), put forearm on the box (laterally), extension of the elbow (lateral), extension of the elbow (lateral) with weight, put the hand on the table (face), then on the box (face), put weight on the box, pull the weight, take a can, keep a pencil, pick up a paper clip, stack pawns, return cards, grip strength, turn a key in a lock, fold a towel, raise a basket.	There are few exercises allowing to evaluate an isolated motion. Most exercises worked with many movements.	The combination of motions assessment but also functional tasks and evaluation of the strength; many tasks are timed. It rates every task by 0 to 5 points (evaluation of the gestural quality), with a maximum score of 75 points. It also has good interrater reliability and validity.	Takes approximately 30 to 45 minutes. Due to its complexity, it requires a training of the therapist before performing it with patients. Needs a lot of material (standardized table, towel, basket, can, pen, paper clip, lock, key). Evaluation of too many tasks compared to specific movements.

Table 3: Primary movements of the 3 motor assessment scales:

Scales	Tasks	primary movements (X: used and N: non-used)						
		Shoulder Flexion	*Shoulder Abd-Adduction*	*Shoulder Int- Ext. Rotation*	*Elbow Flexion*	*Elbow Extension*	*Wrist palmar flexion, dorsiflexion*	*radial and ulnar deviation*
Frenchay Arm Test	stabilize a ruler	N	N	N	N	N	N	N
	draw a straight line	N	X	N	N	N	N	N
	grasp a cylinder and lift it	X	N	N	N	N	N	N
	comb his hair	X	N	N	X	N	N	X
	drink a glass of water	X	N	N	X	N	N	X
	open a cloth peg	N	N	N	N	N	N	N
Wolf Motor Function Test	Put forearm on the table (laterally)	N	X	N	X	N	N	N
	Put forearm on the box (laterally)	N	X	N	N	N	N	N
	Extension of the elbow (lateral)	N	N	X	N	X	N	N
	Extension of the elbow (lateral) with weight	N	N	X	N	X	N	N
	Put the hand on the table (face)	X	N	N	X	X	N	N
	Put the hand on the box (face)	X	N	N	N	X	N	N
	Put weight on the box	X	N	N	N	X	N	N
	Pull the weight	N	N	X	X	N	N	N
	Lift a can	X	N	N	X	X	N	X
	Lift a pencil	X	N	N	N	N	N	N

	Pick up a paper clip	X	N	N	X	X	N	N
	Stack pawns	X	N	N	N	X	X	X
	Return cards	X	X	N	X	X	X	X
	Turn a key in a lock	X	N	N	N	X	X	X
	Fold a towel	X	X	N	X	X	N	N
	Raise a basket	X	X	X	X	X	X	N
Fugl-Meyer Upper Limb	Flexor synergy	X	N	N	X	N	N	N
	Extensor synergy	N	N	N	N	X	N	N
	Hand to lumbar spine	X	X	X	X	N	N	N
	Shoulder flexion 0°-90°	X	N	N	N	X	N	N
	Forearm pro-supination	N	N	N	X	N	N	N
	Shoulder abduction 0°90°	N	X	N	N	X	N	N
	Shoulder flexion 90°-180°	X	N	N	N	X	N	N
	Pro-supination	X	N	N	N	X	N	N
	Wrist repeated dorsi-palmar flexion	N	N	N	X	N	X	N
	Circumduction	N	N	N	X	X	X	X
	Hand mass flexion	N	N	N	N	X	N	N
	Hand mass extension	N	N	N	N	X	N	N
	Flexion in PIP and DIP, extension in MCP	N	N	N	N	X	N	N
	Thumb adduction	N	N	N	N	X	N	N
	Opposition	N	N	N	N	X	N	N
	Cylinder grip	N	N	N	N	X	N	N
	Spherical grip	N	N	N	N	X	N	N

Figure legend :

fig.1 : MindMotionPRO Virtual Reality based neurorehabilitation system.

Fig.2 : 3D virtual environment from an elevated first-person perspective, with the 4 motions (point, reach, grasp, cut fruits).

Fig.3: Mirror mapping: (a) The midline of the body is defined and the movements of the two arms are reversed with respect to the mid-sagittal plane, (b) Mirroring of position: Right-hand movements towards the right correspond to left-hand movements. (c) Mirroring of rotation: Clockwise right-hand movements correspond to counter- clockwise left-hand movements.

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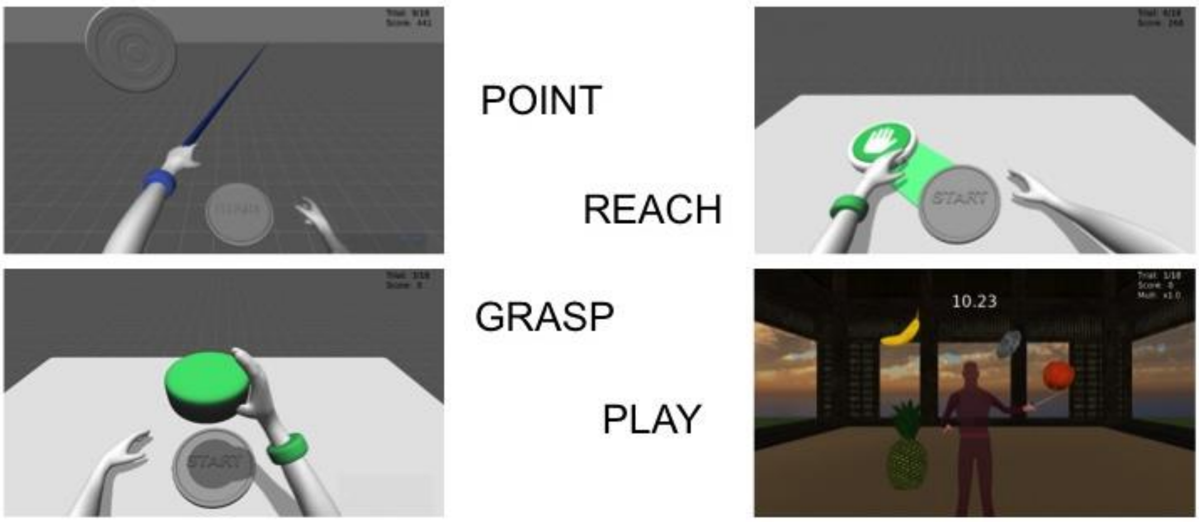
Figure

Figures :

1)

2)



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