ICRAN2015

International Conference on Recent Advances in Neurorehabilitation 2015

June 11th - 12th, 2015 Valencia (Spain)

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David B. Arciniegas (Colorado School of Medicine, Aurora, Colorado, USA)

Venue

Palacio de Congresos de Valencia
Avenida de las Cortes Valencianas, 60, 46015 València, Valencia

Schedule

Jueves 11 de junio

08:00 – 09:00	**Welcome and registration**
09:00 – 09:10	**Welcome address**
09:10 – 09:50	**Michael Gazzaniga** *Plasticity following split-brain surgery*
09:50 – 10:30	**Nick Ward** *Can neuroimaging improve the delivery of neurorehabilitation?*
10:30 – 10:50	**Coffee break**
10:50 – 12:30	**Podium presentations (5 best contributions)**
12:30 – 13:30	**Lunch**
13:30 – 14:15	**Michael Boninger** *Brain-computer interfaces*
14:15 – 14:50	**Olaf Blanke** *Cognetics in neuroscience and rehabilitation*
14:50 – 15:20	**Coffee break**
15:20 – 17:00	**Poster session (One-minute poster session)**
18:00 – End	**Gala dinner**

Jueves 11 de junio

08:00 – 09:00	**Welcome and registration**
09:00 – 09:50	**Michael Merzenich** *Neuroplasticity-based strategies applied to delay onsets of-and to treat-psychiatric and neurological disorders*
09:50 – 10:30	**John Krakauer** *Rethinking motor rehabilitation after stroke*
10:30 – 10:50	**Coffee break**
10:50 – 12:30	**ICRAN session** **David Arciniegas** *Attention and memory problems after mild traumatic brain injury: new perspectives on an old problem* **Steven Laureys** *New technologies for better care of post-comatose states* **Discussion**
12:30 – 13:30	**Lunch**
13:30 – 14:15	**Roger Gassert** *Re-engineering robot-assisted rehabilitation*
14:15 – 15:00	**Paul Verschure** *Towards a deductive medicine of neurorehabilitation: validating the distributed adaptive control theory of mind and brain in the clinic and at home with the Rehabilitation Gaming System*
15:00 – 15:30	**Coffee break**
15:30 – 17:00	**Poster session**
17:00 – 17:10	**Closing remarks**

Keynote speakers

Michael Gazzaniga

PhD; University of California, Santa Barbara, CA, USA

Michael Gazzaniga is the Director of the Sage Center for the study of Mind at the University of California, Santa Barbara. In 1964 he received a Ph.D from the California Institute of Technology, where he worked under the guidance of Roger Sperry, with primary responsibility for initiating human split-brain research. In his subsequent work he has made important advances in our understanding of functional lateralization in the brain and how the cerebral hemispheres communicate with one another. He has published many books accessible to a lay audience, such as The Social Brain, Mind Matters, Nature's Mind, The Ethical Brain, Human and Who's in Charge? Free Will and the science of the brain. Dr. Gazzaniga's teaching and mentoring career has included beginning and developing Centers for Cognitive Neuroscience at Cornell University Medical Center, University of California-Davis, and Dartmouth College He founded the Cognitive Neuroscience Institute and the Journal of Cognitive Neuroscience, of which he is the Editor-in-Chief Emeritus. Dr. Gazzaniga is also prominent as an advisor to various institutes involved in brain research, and was a member of the President's Council on Bioethics from 2001-2009. He is a member of the American Academy of Arts and Science, the Institute of Medicine and the National Academy of Sciences. His new book is Tales from Both Sides of the Brain.

Michael Merzenich

PhD; University of California, San Francisco, CA, USA

Dr. Merzenich's research interests have included the functional organization of the somatosensory and auditory nervous systems; the neurological bases of — and rules governing — learning-induced cortical plasticity; and the neurological origins of and remediation of developmental and acquired impairments in language, reading, memory, attention, cognitive control, and movement. His research teams have extensively modeled changes induced in the brain a) following brain injury and stroke; b) resulting from distorted experiential history leading to acquired impairments, psychotic illness and addiction; and c) contributing to pathological neurological regression in aging.

All have been studied as platforms for developing brain plasticity-based medical therapeutics to treat those conditions in human populations. Dr. Merzenich led a research team that created a widely commercially applied cochlear implant (Advanced Bionics' Symbion). In 1996, he co-founded Scientific Learning, a company dedicated to delivering remedial therapies to address language, reading, attention, and cognitive impairments in school age children. Its programs have been applied to help more than 5 million children. In 2002, he co-founded Posit Science, which produces and delivers computer-delivered therapies applied to help aging, psychiatrically-impaired, and brain-injured populations. In 2009, he co-founded the Brain Plasticity Institute, a research company focused on developing new treatment strategies for children and adults with severe neurological impairments.

Steven Laureys

PhD, Coma Science Group at the Cyclotron Research Center, Dept. of Neurology, Sart Tilman Liège University Hospital, Belgium.

Steven is Clinical Professor (ULg) and Research Director (tenure) at the Belgian National Fund of Scientific Research (FNRS). He graduated as a Medical Doctor from the Vrije Universiteit Brussel Belgium, in 1993. While specializing in Neurology he entered a research career and obtained his M.Sc. in Pharmaceutical Medicine working on pain and stroke using in vivo microdialysis and diffusion MRI in the rat (1997). Drawn by functional neuroimaging, he moved to the Cyclotron Research Center at the University of Liège, Belgium, where he obtained his Ph.D. (2000) and his "thèse d'agrégation de l'enseignement supérieur" (2007) studying residual brain function in coma, vegetative, minimally conscious and locked-in states .

He is board-certified in neurology (1998) and in palliative and end-of-life medicine (2004) and presently is invited professor at the Collège Belgique (Belgian Royal Academy of Sciences) and chair of the "European Neurological Society Subcommittee on Coma and disorders of consciousness".

He is a member of the American Academy of Neurology Committee for the Development of Practice Guidelines for the Vegetative and Minimally Conscious State (2007) (Robert G. Holloway, Dan Larriviere, Michael A. Williams), is Honorary International Fellow of the Royal Hospital of Neuro-disability, London, UK (Keith Andrews) and was invited member of the 2004 Congress on Life-Sustaining Treatments in the Vegetative State organized by the Vatican's Pontifical Academy of Life (Gian Luigi Gigli) and the 2006 Mohonk Consensus Meeting for the US Congressional Report on Disorders of Consciousness (Joseph Giacino).

Michael Boninger

MD; University of Pittsburgh Medical Center, USA

Dr. Michael Boninger is a Professor and UPMC Endowed Chair in the Department of Physical Medicine & Rehabilitation at the University of Pittsburgh, School of Medicine and Director of the UPMC Rehabilitation Institute. He is a physician researcher for the United States Department of Veterans Affairs (VA) and is the Medical Director of the Human Engineering Research Laboratories, a VA Rehabilitation Research and Development Center of Excellence. Dr. Boninger has an extensive publication record of over 200 papers in the areas of spinal cord injury and technology. The technologies Dr. Boninger has investigated vary from brain computer interfaces to wheelchairs. His central focus is on enabling increased function and participation for individuals with disabilities through development and application of assistive, rehabilitative and regenerative technologies. Dr. Boninger also has extensive experience and publications related to training researchers. His students have won over 50 national awards. Dr. Boninger holds 4 United States patents and has received numerous honors, including being inducted into the Institute of Medicine of the National Academy of Science in 2013.

David Arciniegas

PhD; Baylor College of Medicine, TIRR Memorial Hermann, Houston, TX, US

Dr. Arciniegas received his medical degree from the University of Michigan in 1992, after which he completed an internship in community medicine, residency in psychiatry, and fellowship in neuropsychiatry and clinical neuroscience research at the University of Colorado School of Medicine.

Concurrent to his fellowship at that institution, he completed a research grant-supported, three-year fellowship in Neuroscience Research and Traumatic Brain Injury at the Denver Veterans Affairs Medical Center. After completing his fellowships, he was awarded a traumatic brain injury-focused Research Career Development Award by the Department of Veterans Affairs, joined the faculty of the departments of Psychiatry and Neurology at UC-SOM, and was appointed Medical Director of the Brain Injury Unit at HealthONE Spalding Rehabilitation Hospital in Aurora, Colorado.

Since that time, he has published more than 100 peer-reviewed articles in scientific journals, edited four major textbooks on neuropsychiatry and brain injury medicine, and conducted more than 30 externally funded research studies. He is on the editorial boards of Brain Injury, Journal of Head Trauma Rehabilitation, and Journal of Neuropsychiatry and Clinical Neurosciences, and is an editor on four major textbooks in the field, including Management of Adults with Traumatic Brain Injury.

Dr. Arciniegas is the current president of the International Brain Injury Association and participates in governmental and nongovernmental organizations striving to improve the lives of persons and families affected by brain injuries.

Olaf Blanke

PhD; Swiss Federal Institute of Technology, Lausanne, Switzerland

Olaf Blanke is founding director of the Center for Neuroprosthetics and Bertarelli Foundation Chair in Cognitive Neuroprosthetics at the Ecole Polytechnique Fédérale de Lausanne (EPFL). He also directs the Laboratory of Cognitive Neuroscience at EPFL and is Professor of Neurology at the Department of Neurology at the University Hospital of Geneva. Blanke's human neuroscience research is dedicated to the understanding of how the brain represents our body and the neuroscientific study of consciousness using human neuroimaging techniques. In clinical neuroscience he pursues invasive neurosurgical investigations as well as neuroprosthetics investigations in neurological, orthopaedic, and psychiatric patients. He pioneered cognitive neuroprosthetics by using engineering techniques such as robotics, haptics, virtual reality and most became interested in developing cognetics: robotics to study mind, cognition, and consciousness.

John Krakauer

MD; Johns Hopkins University, Baltimore, MD, USA

John Krakauer is Director of the Brain, Learning, Animation, and Movement Lab (BLAM-lab) at The Johns Hopkins University School of Medicine. His areas of research interest are: (1) Experimental and computational studies of motor control and motor learning in humans (2) Tracking long-term motor skill learning and its relation to higher cognitive processes such as decision making. (3) Prediction of motor recovery after stroke (4) Mechanisms of spontaneous motor recovery after stroke in humans and in mouse models (5) New neuro-rehabilitation approaches for patients in the first 3 months after stroke. He has also co-founded a video gaming group called KATA, which is based on the idea that animal movement based on real physics is highly pleasurable and that this pleasure is hugely heightened when the animal movement is under the control of our own movements. This synchronized mapping between a virtual animal's complex movements and our own simpler movements is a cognitive interface of huge potential as it harnesses mechanisms of embodiment, playful motor exploration, and captures the hierarchical organization of the motor system itself. We would also argue that it is an experimental prototype of what lies at the heart of playing and observing sports and dance. The simulated dolphin has now been interfaced with an FDA-approved 3D exoskeletal robot in BLAM-lab in preparation for an upcoming trial.

Roger Gassert

PhD; Swiss Federal Institute of Technology, Zürich, Switzerland

Roger Gassert is associate professor of rehabilitation engineering at the Department of Health Sciences and Technology at the ETH Zurich. He received his M.Sc. degree in microengineering and a Ph.D. degree in neuroscience robotics from the Ecole Polytechnique Fédérale de Lausanne (EPFL) in 2002 and 2006, respectively. His main research interests include physical human-robot interaction, rehabilitation and neuroscience robotics, assistive technology and the neural control of movement. He is one of the pioneers in the field of neuroscience robotics to investigate sensorimotor control and related dysfunctions following neurological injury, and has made significant contributions to robot-assisted assessment and therapy, with a special focus on sensorimotor hand function. Dr. Gassert has co-authored over 100 peer-reviewed publications and is co-inventor of 8 patents. He is a senior member of the IEEE, member of the foundation board of the Swiss Foundation for Rehabilitation Technology and the Swiss foundation Access for all, as well as Swiss national contact point of the Association for the Advancement of Assistive Technology in Europe.

Paul Verschure

PhD; University Pompeu Fabra, Barcelona, Spain

Dr. Verschure's scientific aim is to find a unified theory of mind, brain and body through the use of synthetic methods and to apply such a theory to the development of novel cognitive technologies. Dr. Verschure works on biologically constrained models of perception, learning, behavior and problem solving that are applied to wheeled and flying robots, interactive spaces and avatars. The results of these projects have been published in leading scientific journals including Nature, Science, PLoS and PNAS. In addition to his basic research, he applies concepts and methods from the study of natural perception, cognition and behavior to the development of interactive creative installations and intelligent immersive spaces. Since 1998, he has, together with his collaborators, generated a series of 25 public exhibits of which the most ambitious was the exhibit "Ada: Intelligent space" for the Swiss national exhibition Expo.02, that was visited by 560000 people. The most recent one was the Multimodal Brain Orchestra that premiered in the closing ceremony of the EC Future and Emerging Technologies conference in Prague in April 2009.

Dr. Verschure leads SPECS, a multidisciplinary group of over 30 pre-doctoral, doctoral and post-doctoral researchers that include physicists, psychologists, biologists, engineers and computer scientists supported by his own technical and administrative staff.

Nick Ward

MD; University College London, UK

His special clinical interest in in stroke and neurorehabilitation and in particular the assessment and treatment of upper limb dysfunction. His research is concerned with understanding the mechanisms of upper limb impairment and treatment after stroke. In particular, he uses structural and functional brain imaging techniques to study the relationship between brain network reorganization and recovery of motor function after stroke.

Contributions

Oral communications

Poster communications

Oral communications

Effects of surgery and early rehabilitation treatment on equino-varus foot deformity. Gait changes at one and three months after treatment assessed by a tri-axial accelerometer

Maria Longhi[1], Davide Mazzoli[1], Paolo Zerbinati[1], Erika Giannotti[1,2], Andrea Merlo[1], Paolo Prati[1]

[1]Gait & Motion Analysis Laboratory of Sol et Salus Hospital, viale San Salvador 204, Rimini, Italy.
[2]Department of Orthopaedic Rehabilitation of University of Padova, Padova, Italy
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Introduction

Equino-varus foot deformity (EVFD), the most characteristic deformity after stroke, compromises several prerequisites of walking with an important reduction of smoothness and symmetry during gait. In this work, we used an accelerometer to monitor the recovery of walking ability in stroke patients with EVFD surgically treated.

Methods

Gait of a consecutive sample of 12 hemiplegic patients (52±11 years old, 6 Right, 4±2 years from stroke, FAC 2-5, WHS 3-6, 6mWT 37-390 m) was assessed by a tri-axial accelerometer (GWalk, BTS, Milan) before, at 1 and 3 months after surgical correction of EVFD. Interventions were performed by a single surgeon and followed by a standardized rehabilitation protocol beginning at day 1 after surgery. Robust algorithms were developed to automatically identify gait events from the acceleration profiles of slow and very slow walking stroke patients. Step time, cadence, symmetry [1] and smoothness [2] indices were computed based on the fore-aft acceleration component.

Results

Cadence improved at 1 month after surgery (from 61±24 step/min to 72±23, Wilcoxon test, $p<0.05$) and was maintained at 3 months. Smoothness (number of peaks per step) showed a progressive increase in time with statistical significant variation at 3 months after treatment ($p<0.05$) (Figure 1). Symmetry index presented a different trend in our sample. At 1 month after surgery 9 patients had a variations towards normality and at 3 months 6 of these presented further improvement while 3 patients returned to asymmetric gait. In the rest of sample, 3 hemiplegic patients, we observed a worsening at 1 month with a partial recovery at 3 months after treatment (Figure 2). These 3 subjects presented at the evaluation before surgery the worst walking ability (unable to walk with either unassisted or without orthotic devices).

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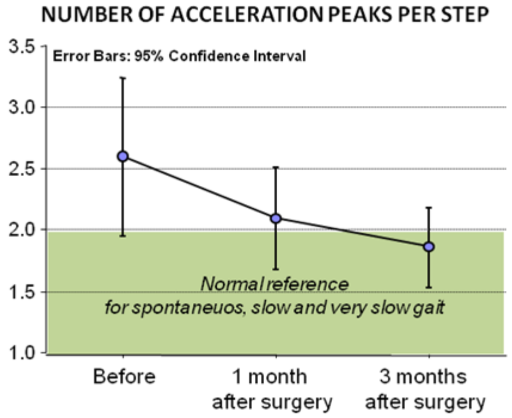

Figure 1. Time evolution of a smoothness index

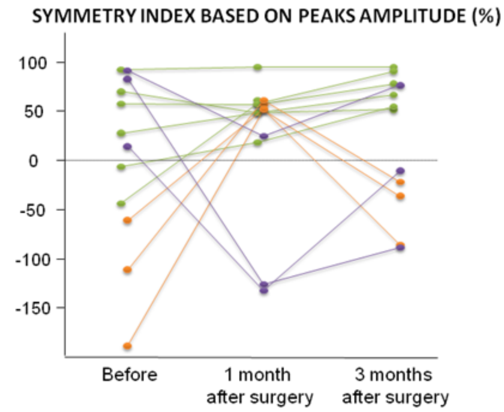

Figure 2. Time evolution of one of the symmetry indices in the sample. This index becomes negative in case of large asymmetry (e.g.: PeakL/PeakR >3).

Conclusions

Cadence improved at 1 month after surgery (from 61±24 step/min to 72±23, Wilcoxon test, $p<0.05$) and was maintained at 3 months. Smoothness (number of peaks per step) showed a progressive increase in time with statistical significant variation at 3 months after treatment. Symmetry index presented a different trend in our sample. At 1 month after surgery 9 patients had a variations towards normality and at 3 months 6 of these presented further improvement while 3 patients returned to asymmetric gait. In the rest of sample, 3 hemiplegic patients, we observed a worsening at 1 month with a partial recovery at 3 months after treatment. These 3 subjects presented at the evaluation before surgery the worst walking ability (unable to walk with either unassisted or without orthotic devices).

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3. Merlo A., *Upper limb evaluation with robotic exoskeleton. Normative values for indices of accuracy, speed and smoothness*, Neurorehabilitation, 2013. 33(4): 523-30.

Instrumental indices for the upper limb function assessment in stroke patients. A concurrent validity study

Maria Longhi[1], Andrea Merlo[1], Paolo Prati[1], Meris Giacobbi[1], Emilia Ruscelli[1], Davide Mazzoli[1]

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Introduction

Robotic exoskeletons are increasingly being used in upper limb (UL) rehabilitation. We developed a software that boosts the capability of Armeo®Spring device in the assessment of reaching movements by providing indices of accuracy, velocity and smoothness [1]. In this study we tested concurrent validity of these instrumental indices by comparing them to Wolf Motor Function Test (WMFT) [2], a clinically validated scoring system, in a sample of stroke patients.

Methods

Twenty-two stroke patients, 45-79 years old, WMFT range 10-75 and Motricity Index (MI) range 9-33 at shoulder and elbow were enrolled. Residual UL function was assessed at admission and after 12 rehabilitation sessions (40 minutes, 3 session/week) through both WMFT score and time and a set of numerical indices computed by the software based on the 3D end-point trajectory during Vertical Capture task of Armeo®Spring. Four indices assessed the accuracy: global Hand Path Ratio (HPR), local HPR in the area of the target (locHPR), vertical and horizontal overshoot (vertOS, horOS). Two indices assessed the maximum and mean velocity (maxVel, meanVel). Three indices assessed the smoothness: mean/maximum velocity ratio (meanVel/maxVel), number of peaks in the velocity profiles (NVelPeaks), and normalized jerk (NormJerk). These indices were compared to WMFT score and time by the non-parametric Spearman's correlation coefficient.

Results

Forty-four instrumental assessments on 22 patients were considered. WMFT scores were distributed between 10 and 75. One accuracy index (HPR), both velocity indices and all smoothness indices were strongly correlated with WMFT score and time ($p<0.05$) (Table 1). Moreover, the indices were able to detect differences in either accuracy, velocity or smoothness in patients with the same WMFT score and time.

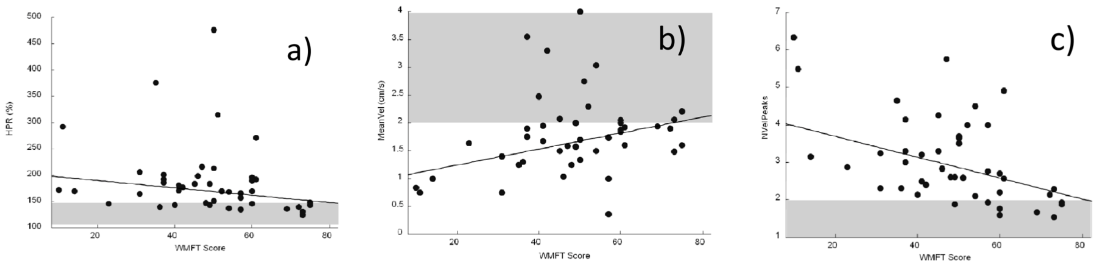

Figure 1. Relationship between WMFT score and a) Hand Path Ratio as a percentage of the straight path (HPR%), b) endpoint mean velocity and c) average number of peaks in the endpoint trajectory among reaching tasks for 44 assessments of 22 subjects with two evaluations (before and at the end of the treatment). Each dot in Figure 1 represents a subject evaluation. The regression lines outline the presence of a linear relationship between WMFT and instrumental variables. Interestingly, a few subjects show a peculiar behavior, with values lying far from the regression line. Gray bands indicate the normal reference band for each variable.

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Indices	Normal reference	Sample Mean Value	P-Value
HPR, %	137±38	187±67	<0.0001*
horOS, cm	1±2	2±1	<0.001*
vertOS, cm	1±2	1±1	0.414
locHPR, %	180±145	250±217	0.128
meanVel, cm/s	3±2	2±1	0.003*
maxVel, cm/s	8±5	6±3	0.033*
meanVel/maxVel	37±9	33±4	0.003*
NVelPeaks	2±1	3±1	<0.0001*
NormJerk	201±422	9204±19714	<0.0001*

Table 1. Spearman's correlation coefficient rho and statistical significance (P Value) between the instrumental indices assessing the trajectory precision, velocity and smoothness during Armeo@Spring-assisted upper limb reaching task and both WMFT score and time. Bold is used to highlight the statistically significant correlations ($P < 0.05$). See text for more details.

Conclusions

The instrumental indices computed by the software applied to Armeo®Spring showed concurrent validity with WMFT score and time thus being usable to integrate and support the clinical evaluation of the UL functionality in patients affected by stroke.

The developed instrumental assessment tool can outline the differences in the UL motor impairment among patients classified at the same functional level by the WMFT. Moreover, they can also be used to customize the rehabilitation treatment for the individual patient's goals, to improve the sensitivity in detecting motor pattern changes over time and demonstrating the treatment efficacy.

References

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2. Wolf S.L., *Assessing Wolf Motor Function Test as outcome measure for research in patients after chronic stroke*, Stroke, 2001. **32**(7): 1635-9.

Effects of theta-burst stimulation on word learning

Pierre Nicolo[1,2], Raphaël Fargier[3], Marina Laganaro[3], Adrian G. Guggisberg[1,2]

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Introduction

Aphasia is a common disability after brain damage. Repetitive transcranial magnetic stimulation (rTMS) is a promising neuromodulation technology which may be able to enhance naming performance [1]. However, the effect of rTMS on brain organization and clinical recovery are insufficiently understood. In particular, we do not know whether rTMS has a facilitatory effect on learning. This would be important for an add-on therapy in rehabilitation, as it would allow boosting standard speech therapy. The aim of this sham-controlled study was to assess the effects of continuous theta burst stimulation (cTBS), an inhibitory form of rTMS [2], on learning new vocabulary in healthy participants.

Methods

16 young participants without neurological disease were alternatively trained in two picture naming lists including very low frequency items immediately after cTBS or sham stimulation applied to the right inferior frontal gyrus (IFG). One day after each training session, the increase in correctly named pictures in comparison to baseline was measured. To characterize neural changes, we performed EEG resting-state and event-related functional connectivity as well as event-related potential and event-related power analysis at the source level. Selected regions of interest were based on a priori knowledge of the language network and localization tasks. Finally, we investigated their association with naming performance.

Results

On the behavioral level, participants showed learning effects ($p<0.00$), but there was no significant difference between cTBS and sham stimulation ($p=0.67$). On the neural level, the naming task induced a significant increase in high-gamma power (55-95 Hz) at a left temporo-occipital region between 400 and 800 ms after stimulus presentation ($p<0.05$, FDR corrected). One day after cTBS-modulated learning, event-related delta and theta power at this area was significantly enhanced, while it was reduced one day after sham stimulation followed by learning ($p<0.05$, FDR corrected). These changes were observed for learned as well as non-learned words and did not correlate with behavioral learning. No long-term effects were observed for high-gamma power, event-related potentials, event-related coherence, or resting-state coherence. However, correlation analysis revealed that cTBS reduced resting state alpha-band coherence between the right IFG and the rest of the brain in subjects in whom coherence before stimulation was high. The coherence reduction was correlated with better learning ($r^2=0.4$, $p=0.01$).

Conclusions

Neural power changes induced by lexical learning can be modified by one session of cTBS, and this effect persists at least one day after stimulation. Nonetheless, these neural changes do not necessarily translate into improved learning performance in picture naming tasks. At rest, functional coupling might be suitable to predict the behavioral response to non-invasive

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stimulation. A better understanding of the neural mechanisms of learning and their modulation with rTMS might enable to target critical processes more efficiently.

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A two weeks high-intensity task-oriented circuit training in chronic stroke survivors: transcranial direct current stimulation might help?

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Introduction

Stroke is one of the major causes of disability in the worldwide and in the acute phase, more than 80% of patients suffer from mobility and gait impairments. Furthermore, in chronic phase approximately 21% of patients experience a significant decrease in mobility due to inactivity [1]. Intensity and specificity of motor tasks are essential key factors of learning-dependent neural plasticity and the amount of practice might influence functional recovery after stroke [2]. Task oriented circuit training (TOCT) is an example of an intense task-specific intervention, based on workstations that reproduce physical activities that the subject usually performs during daily living (i.e. walking, climbing stairs, maintain balance) with the aim of promoting motor learning and task retention. Previous studies [3] demonstrated how TOCT is a good method to improve locomotor functions and mobility in stroke survivors. Moreover, additional benefits of circuit class therapy related to the peer support and social interaction provided by the group environment might be reported [3]. Recently, transcranial direct current stimulation (tDCS) has been proposed as a non-invasive tool to increase motor recovery in people who suffer from a stroke [4], however few data are available on the effects on gait function and mobility [5]. Furthermore, the best timing of combining tDCS with behavioral interventions (pre, post or during rehabilitation) and the most effective stimulation montage and protocol are still unknown. The aims of this proof-of-concept study were threefold: (i) to test the feasibility and preliminary effects of an high-intensity 2 weeks task-oriented circuit training in chronic stroke survivors; (ii) to test if the combination with tDCS might add further benefits; (iii) to verify the best timing for applying the neuromodulation (pre- or post-treatment).

Methods

Twenty subjects with chronic stroke were enrolled (13 males, 7 females, 63.85±2.12 years, stroke onset 5.20±1.56 years). They were tested under three stimulation conditions: (1) anodal tDCS prior to TOCT (n=5); (2) anodal tDCS after TOCT (n=6) and (3) sham tDCS before TOCT (n=9). Real-tDCS group received anodal tDCS for 15 minutes, (anode on affected lower limb M1, cathode on the forehead above the contralateral orbit as reference electrode). Sham-tDCS group received 20 seconds of stimulation. Each subject underwent 10 sessions of TOCT (5 sessions / week) over two weeks. Clinical outcome measures were: (i) Six Minute Walk Test (6MWT), (ii) 10 Meter Walk Test (10MWT) and (iii) Timed Up & Go Test (TUG). The evaluations were performed the week prior to treatment initiation (T0), the week after the end of treatment (T1) and at 3 months follow-up (T2).

Results

Sample characteristics are summarized in Table 1. At baseline, no between-group differences were highlighted. The whole group (n=20) significantly increased their gait speed ($p<0.01$), walking endurance ($p<0.01$) and mobility ($p<0.05$) after TOCT (median: 0.08 m/s; 19.4 m; -0.90 s) with good retention at 3 months (median: 0.09 m/s; 22.9 m; -0.81 s). Both real-tDCS and sham-tDCS group showed an overall improvement ($p<0.01$) in gait speed; however only real-

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tDCS group increased walking endurance ($p<0.01$) by 20m after TOCT and 28.6m at 3 months. Specifically, among the real-tDCS groups, only subjects that received tDCS before TOCT, increased significantly their walking endurance ($p<0.01$). All participants tolerated tDCS well without experiencing significant adverse effects.

	Real tDCS (n=11)	Sham tDCS (n= 9)	P value
Age (years)	61	67.33	0.14
Sex (M/F)	9/2	4/5	0.08
Stroke type (ischemic/hemorrhagic)	8/3	6/3	0.63
Stroke onset (years)	4.87	5.61	0.81
Side hemiparesis (left/right)	3/8	5/4	0.07
Lesion type (SC/CSC)	4/6	6/2	0.13
FAC	4.55	3.89	0.06

Table 1. Sample characteristics. FAC = functional ambulation classification; SC = subcortical, CSC=cortical-subcortical.

Conclusions

A high-intensity 2 weeks TOCT seems to increase walking endurance and walking speed in chronic stroke survivors. The additional use of tDCS might add further gains in walking endurance if applied before-training. Further research on a larger sample and different protocols it will be necessary to explore the use of tDCS as an adjuvant treatment strategy in walking rehabilitation after stroke.

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Automated Fugl-Meyer assessment for acquired brain injury subjects in upper limb physical neurorehabilitation

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Introduction

A demand for automated assessment techniques arises due to the increasing number of patients with stroke and the continuous growth of new treatment options [1]. Upper limb (UL) motor/physical/functional assessment is focused on clinical tests highly dependent on the criteria and experience of the examiner. Fugl-Meyer assessment (FMA) scale is one of the most widespread tests in the clinical practice and scientific literature [2]. New technologies allow analyzing ABI subjects UL motion using different methods such as: Kinematic analysis and modeling of Activities of Daily Living [3]. This research is based on objective motor assessment (OMA) methodology [4]. As a first stage, two FMA items of the UL Flexor Synergy (FS) and Extensor Synergy (ES) are automated; it could be extended to other FMA items. The main goal of this research is to automatically estimate an objective measurement (*OMA-score*) for FS and ES.

Methods

The automation of FS and ES items consists of five stages: (1) Motion data acquisition of 42 healthy subjects and 7 ABI subjects, using the BTS-SMART-D system [5]. (2) Generation of reference healthy kinematic models, applying a biomechanical model of nine Degrees of Freedom (DoF). (3) Selection of the most relevant DoFs for each FMA item [6]. Table 1 shows both the instructions and the most relevant DoFs by item. (4) Calculation of the Motion Parameters (MP) associated to each DoF; this MPs are obtained by processing the following metrics: range of motion (ROM), root mean squared error (RMSE), Pearson correlation coefficient (CC) and the item adapted metric (IAM), that is calculated by analyzing the biomechanical configuration of the patient's UL in those landmarks specified by the FMA. MPs are used to identify the similarity between the healthy kinematic model and ABI subject motion. These MPs form a vector characterizing the physical alterations of the subjects [4]. (5) Calculation of *OMA-score* is performed by averaging all the values of the MPs, indicating the level of motor impairment. The same scoring criteria of FMA are used (0-2, for each DoF).

FMA Item	Instructions	Most relevant DoFs
Flexor synergy	The patient should bring his/her forearm fully supinated to the ear of the affected side, the elbow fully flexed, the shoulder abducted to at least 90º, outwards rotated, retracted and elevated. Maximum possible score = 12	eldC (elevation of the shoulder) retaC (retraction of the shoulder) abdS (abduction/adduction of the shoulder) rotS (internal/external rotation of the shoulder) fexE(flexion/extension of the elbow) pronoE (pronation/supination of the forearm)

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Extensor synergy	The patient should adduct/internally rotate the shoulder, extend his arm towards the unaffected knee, forearm pronated. Maximum possible score = 6	abdS rotS fexE pronoE

Table 1. Instructions and most relevant DoFs by FMA item.

Results

Table 2 shows the score calculated by the 2 therapists (T1, T2) that participated in the study along with the automated *OMA-score* for the FS and ES items corresponding to 7 ABI subjects (which is rounded up). As it can be observed, the therapists can assign the same or a different score for the same patient. The fact that two therapists assigned a different score for the same subject when he/she is assessed in the same temporary-space conditions reflects the subjectivity of FMA.

	FS Item			ES Item		
Subjects	T1	T2	OMA-score	T1	T2	OMA-score
S1	12	12	8.6238 (9)	6	6	4.843 (5)
S2	-	-	-	6	6	4.760 (5)
S3	2	4	8.917 (9)	0	0	0
S4	10	8	8.320 (8)	-	-	-
S5	10	12	9.338 (9)	6	6	4.640 (5)
S6	10	12	8.9959 (9)	-	-	-
S7	9	10	10.039 (10)	6	6	5.157 (5)

Table 2. Obtained results in FS and FE items for T1, T2, OMA-score. -: Loss data.

When *OMA-score* is compared with those assigned by the therapists, it can be seen that its values are similar to those assigned by the clinicians in most cases. In order to analyze the mismatch causes in the scores (greater variations are underlined), the most representative case (S3: FS item) is explained: the therapists have assigned a low score to S3 since the subject does not reach the end position of the item; it is difficult for the human eye to detect variations of small scale of the UL movement when there is not enough biomechanical information, however, these variations are identified by the automation of FMA. S3 has the following alterations in the FS item execution:

- retaC: limited ROM (62.5%)
- abdS: limited ROM (29.35%) and impossibility to reach the final position (can only reach to a 20,8% of the required shoulder abduction)
- fexE: ROM (0%) and inability to reach the required final position (0%)

Conclusions

The main novelty of this work resides on the automation and the getting of objective assessment of 7 ABI subjects for FS and ES items. Obtained results indicate that the automation of FMA can be a useful tool for the assessment of ABI subjects, as part of the OMA in UL physical neurorehabilitation.

The main advantages of the automation method of FMA are:

- Provide to therapists an objective tool, giving an *OMA-score* for every item or a *global-OMA-score* for all the FMA items.

- OMA can be used in several different applications: to allow robotic assistance in rehabilitation therapies and to create a useful database about the physical alterations of the subjects for medical research.

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Poster communications

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One source multi-functional and multi-use upper limb training robot for task-oriented training

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Introduction

Various upper limb rehabilitation robots for stroke patients are clinically popular to the clinic hospitals and rehabilitation centers [1]. Rehabilitation robots are still required how to perform the task-oriented training which aims at the recovery of activities of daily living through the motor skill acquisition [2]. The proposed one-source multi-functional and multi-use (OSMU) upper limb training robot can provide the exercises at multi-plane (*i.e.*, sagittal, coronal, and transverse plane motion) and multi-functional trainings (*i.e.*, passive, assistive, active, and resistive exercise). This 4-DOF robot has large workspace with its small size and light weight. The robot has the symmetric five-bar linkage configuration so as to offer the high manipulability. In addition, the wire-driven transmission mechanism can keep high back-drivability and the damping controllable MR damper is adopted in order to make the robot intrinsically stable from a dynamic control point of view. The robot has high allowance for load with its small power and high exertion force enough to transmit large resistive forces and produce high stiffness to rigidly support the human arm. The proposed robot can be utilized to task-oriented training of upper limb for improving the stroke patient's motor functions through the multi-functional and multi-use training. Consequently, we expect that this OSMU upper limb training robot can contribute for the patient to return to his/her daily life.

Methods

The specification of the proposed robot is shown in Table 1. The distinct features of the OSMU upper limb training robot are depicted in Figure 1. Figure 1(a) shows that the symmetric five-bar linkage mechanism has high manipulability in terms of manipulability ellipsoid from the manipulability analysis [3]. The actuating mechanism has two BLDC motors and two MR dampers. Wire-driven transmission can delivered the power from the motor to the links (Figure 1(b)). Figure 1(c) shows the appearance of the OSMU upper limb training robot, the way of 4 DOF motions, and the examples of multi-plane exercises

Variable	Description
Size [mm]	800(W) X 1500(D) X 1000(H)
Weight [kg]	107
Power [W]	150W BLDC Motor, Controllable MR damper
Power Transmission	Wire-Driven
DOF	4(X,Y, Z, θ)
Motion	Sagittal, Coronal, Transverse
Function	Active, Passive, Assistive, Resistive
Allowable Load [N]	Down/Up: 320/320
Exertion Force [N]	50(Active),110(Passive)

Table 1. Specification of the OSMU upper limb training robot

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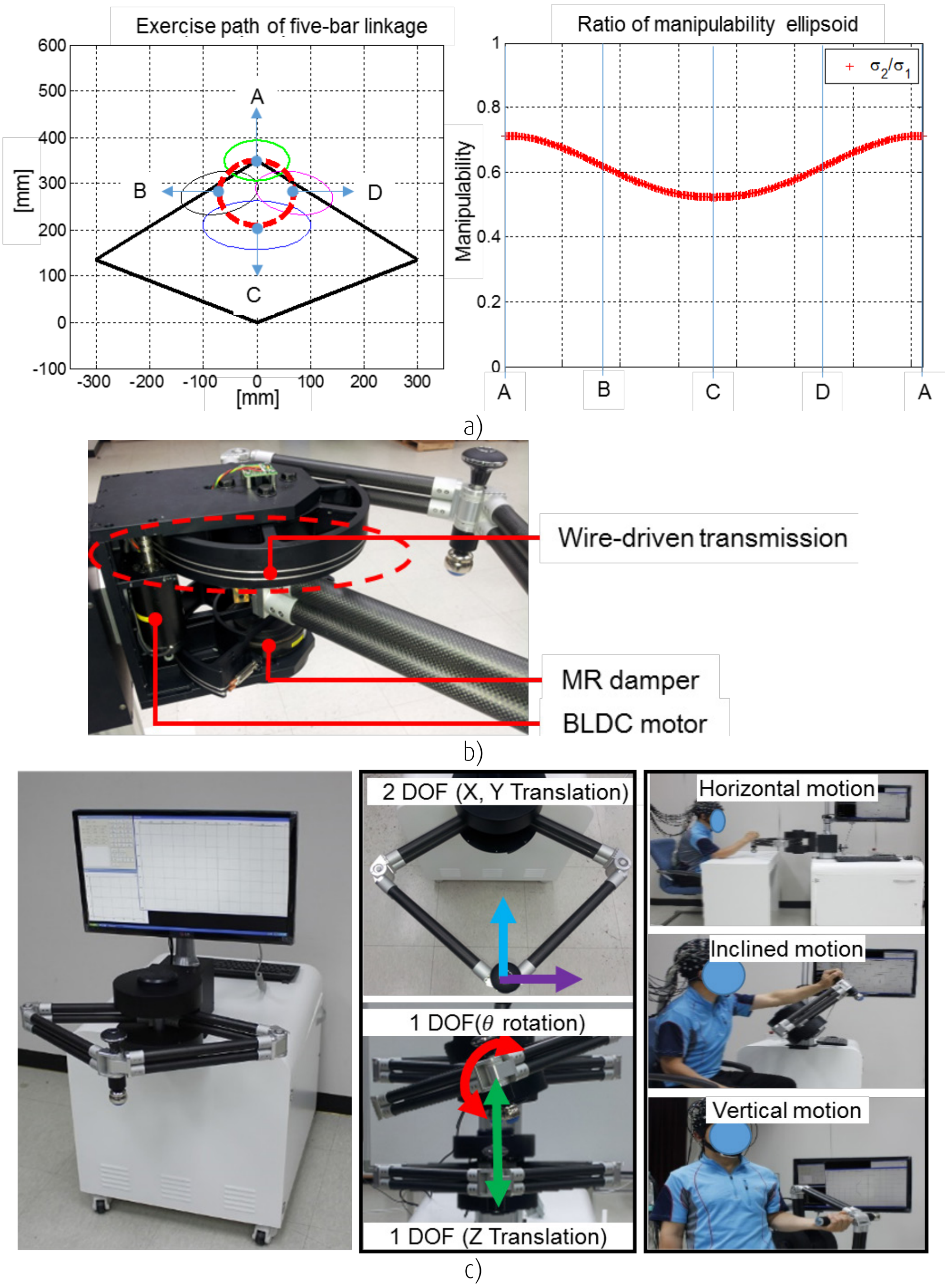

Figure 2. One Source Multi-Functional and Multi-Use Upper Limb Training Robot. a) Manipulability analysis of the five-bar linkage; b) Components of the actuating mechanism; c) general view.

Conclusions

This paper introduces an upper limb rehabilitation robot for stroke patients to be suitable for task-oriented training. This one-source multi-functional and multi-use robot has hybrid actuating concept using DC motor and MR damper to enhance the force controllability with guaranteeing the intrinsic stability. The proposed robot can be distinguished from the commercially available rehabilitation robots by its capability to perform multi-functional training (passive, assistive, active, and resistive exercise) and multi-plane exercise (horizontal, inclined, and vertical motion). Now some further works are remaining. The smaller and compact sized desk top robot will be newly designed to apply to both hospital and home together. Virtual reality based user-

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experience will be created to offer the task-oriented training contents to the patients in order to enhance the immersion and motivation of the training. Clinical trials will be executed to verify usefulness of the one-source multi-functional and multi-use upper limb training robot.

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New therapies in aphasia after stroke

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Introduction

Stroke is one of the leading causes of disability worldwide. Aphasia among stroke survivors is common. Current speech and language therapy (SLT) strategies have only limited effectiveness in improving aphasia. In the era of technologic advances, it is each day more common to hear or read about their application in Rehabilitation.

Methods

We searched the Cochrane Database of Systematic Reviews and PubMed between 2008 and 2015. We included systematic reviews that compared New-rehabilitation-therapies with usual-rehabilitation or no- rehabilitation.

Results

Currently there is no evidence of the effectiveness of transcranial direct current stimulation (tDCS) (anodal tDCS, cathodal tDCS) versus control (sham tDCS). There was no effectiveness regarding surrogate markers of aphasia (that is language function) such the relative change in naming accuracy. However, it appears that cathodal tDCS over the non-lesioned hemisphere might be the most promising approach.

The American Speech-Language-Hearing Association (ASHA) says that telepractice or telehealth is an appropriate model of service delivery for the profession of speech–language pathology (SLP), and may be used to overcome barriers of access to services caused by distance, unavailability of specialists and impaired mobility. The existing literature consists primarily of pilot studies and anecdotal accounts of telehealth applications rather than large, well-controlled, randomized clinical trials.

In 1992, clinicians at the Veterans Affairs Medical Center in Martinez, California conducted a simulation study to compare face-to-face with “remote conditions” in the appraisal and diagnosis of aphasia and dysarthria. The agreement in diagnosis among appraisal conditions was 93% to 94%. Results suggested that either television or computer-controlled video laserdisc by telephone could be substituted for face-to-face sessions.

Since these early studies, many telehealth applications for neurogenic communication disorders have been reported. Nowadays, in USA, telehealth is being used to address the problem of unfilled SLP positions in home healthcare agencies. In Reynold´s review in 2009, concluded that the service delivery results from telehealth were equivalent to traditional face-to-face results. However, telehealth was not a complete replacement for face-to-face service delivery.

Conclusions

There are fewer Innovations in speech therapy than in others areas of neurorehabilitation. Most of them are designed for adapting the patient disability to his community, which it is also important, but they assume the lack of possibilities to improve.

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Telehealth is an appropriate model of service delivery for the profession of speech-language pathology, and may be used to overcome barriers of access to services caused by distance, unavailability of specialists and impaired mobility.

There is a demand for further randomized controlled trials with parallel group design and sample-size estimation in this area. Data on adverse events should be routinely collected and presented in further publications.

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Recovery patterns and predictors of functional outcome after stroke

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Introduction

Functional recovery is considered as an improvement in mobility and activities of daily living. It has long been known that it is influenced by rehabilitation. Various studies have analysed the evolution of patients recovering from a stroke [1].

Although a great deal is known about the neurophysiological mechanisms responsible for recovering from neurological deficits, involving brain reorganization and the mechanism of neuroplasticity [1], a wide variety of functional poststroke recovery patterns have been described by the literature. It has been demonstrated that the main recovery is reached during the first weeks after stroke, while there is still a lack of consensus about when the plateau period following the early recovery occurs [2-8].

Knowledge about factors that determine the functional outcome after stroke is important for early stroke management, patient evaluation, rehabilitation and discharge planning, and guidance of patient and relatives [4]. A large number of factors have been identified as predictors of functional outcomes after stroke. Nevertheless, it has not been found a factor or group of factors that clearly predict poststroke recovery [1,4,8]. The present study aims to clarify the recovery patterns as well as factors predicting functional outcomes in poststroke patients.

Methods

A total of 106 subacute stroke patients were recruited for participation in this retrospective study, performed on patients referred to the specialized rehabilitation service for brain injuries at the Hospital Valencia al Mar (Hospitales Nisa group, Valencia, Spain) from 2000 to 2010. Subjects selected were all aged over 18 and they were in a stable clinical condition. Patients with a diagnosis of congenital, infantile or hemiplegia secondary to intoxication or a brain tumour, or those with a serious neurological condition, were excluded. Scores relative to 10 assessment scales and demographic and clinical characteristics were collected at three assessment times during the course of their rehabilitation: at baseline (assessment 1), after six months (assessment 2) and 12 months (assessment 3).

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
A: Assessment	130.85	2	65.42	79.83	0.0000
Linear comp	119.29	1	119.29	145.56	0.0000
Quadratic comp.	11.56	1	11.56	11.56	0.0000
B: Patient	1640.93	103	15.93	19.44	0.0000
Residual	134.40	164	0.82		
Total (corrected)	1932.32	269			

Table 1. Analysis of Variance for C1 - Type III Sums of Squares. ANOVA of the time course of C1. All F-ratios are based on the residual mean square error

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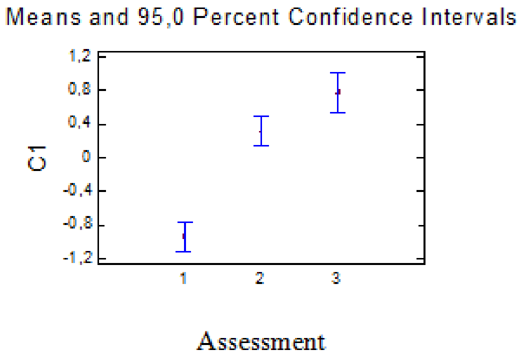

Figure 1. Time course of C1 during rehabilitation

Results

By means of a principal component analysis (PCA) a first component (C1) was obtained, which is taken to represent a combined index of the 10 scales and to express the global health status of the patient. An ANOVA of C1 showed a clear improvement trend, with this being more marked during the first six-month period (72.7%) than the second six-month period (27.3%) (Table 1 and Figure 1). Moreover, the results of a multiple regression analysis reflect the higher significance of the effects of sex, age, chronicity, emotional-conductual status and global health status at baseline.

Conclusions

The stroke patients experimented an initial period of rapid recovery during the first six months, followed by a less marked period of recovery. However, no stabilization period in the patients' progress was found. Global health status at baseline has a positive influence on the degree of the functional recovery, while age, chronicity and emotional-conductual status at baseline. Furthermore, males show a higher degree of recovery compared to women.

Acknowledgements: We thank all participants and professionals from Hospital Valencia al Mar from Valencia, who made this study possible. Specially, we thank Dr. Noé Sebstián and Dr. López Bueno for providing feedback on a draft of the article.

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Cut-off points for functional poststroke assessment scales

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Introduction

Appropriate assessment of post-stroke patients is important for quality care and for measuring clinical outcomes of this population. A wide variety of well-validated instruments for the assessment of functioning and disability have been developed [1-3]. Although validated and globally used for functional assessment the BI, FIM and FAM scales have limitations in their application, such as a difficult interpretation. In order to provide more interpretable information, some assessment scales have been stratified or divided into categories [2].

Several cut-off points have been suggested for the categorization of some of these instruments. The assessment scales most commonly used in order to establish such cut-off points are the BI and the Modified Rankin Scale (mRS) [4-6]. The FIM has also been used in a variety of such studies [2,7]. The categories used with other global disability assessment scales have not been so widely studied. In the case of the Differential Outcome Scale (DOS), such a categorization has only been performed for its four sub-scales, but not for the overall DOS [8].

The purpose of this study is to differentiate clinically distinct categories of disability for the BI, the FIM and the FAM and to determine their cut-off points. ThemRS and the DOS, which have been used to define stroke disability categories, were used as reference and the relationship between these two global disability scales was analyzed.

Methods

This retrospective study was performed on patients referred to the specialized rehabilitation service for brain injuries at the Hospital Valencia al Mar (Hospitales Nisa group, Valencia, Spain) from 2000 to 2010. Subjects selected were all aged over 18and they were in a stable clinical condition, and those in a serious neurological condition were excluded. Using the data available on the patients over a one-year period, the post-stroke assessment total scores for the BI, FIM, FAM, DOS and mRS were collated.

		mRS		
		Severe disability	Severe disability	Severe disability
DOS	Severe disability	93 48.69%	98 51.31%	0 0.00%
	Moderate disability	2 2.25%	84 94.38%	3 3.37%
	Mild disability	0 0.00%	0 0.00%	1 100.00%

Table 1. Contingency table of DOS and mRS disability levels. Kendall's tau-b = 0.475. p-value=0.000

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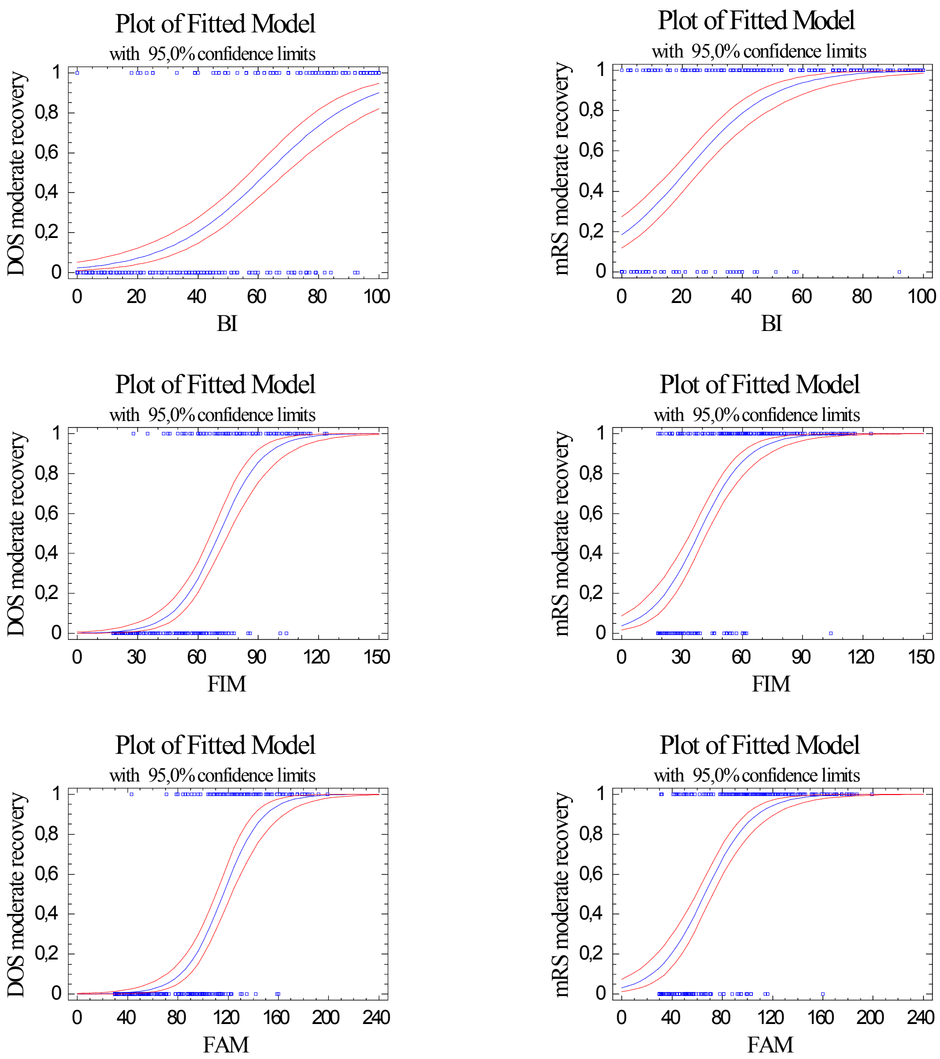

Figure 1. Binary logistic regression models for mRS and DOS moderate disability given BI, FIM and FAM scores.

Results

A total of 106 subjects (45.3% women, 54.7% men) were recruited. The median BI and FIM values were 23.5 and 42, respectively, and the mRS values ranged between 3 and 5, indicating a severe disability in our sample.

The relationships between the different disability levels currently in use with the DOS and mRS scales were determined using a contingency table. A positive correlation was observed between the two ordinal scales, although a certain amount of disagreement between the two scales for the three disability levels was also detected (Table 1).

From the results of binary logistic regression analysis, cut-off points in the BI, FIM and FAM were determined. Given the high level of severity in our sample this study has only focused on the lower cut-off point. These lower cut-off points were obtained by creating a binary logistic regression model for each of the six possible combinations of assessment scales (Figure 1). Ideal cut-off points were defined as the corresponding scores for BI, FIM and FAM that have an equal 50% probability of being located in either of two adjacent DOS and mRS disability levels (severe and moderate disability).

The lower cut-off points (95% CI), separating the levels of severe and moderate disability, in the functional-ADL scales, derived from the cut-off points of the global disability scales (the DOS and the mRS respectively), were: 62.90(57.26-69.29) and 21.30 (16.34-26.03) for the BI;

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70.62 (66.65-75.22) and 38.29 (34.07-42.25) for the FIM; and 116.07 (110.30-122.68) and 66.02 (59.20-72.35) for the FAM.

Conclusions

In this study a high correlation between mRS and DOS was determined and the DOS scale was found to be more demanding than the mRS, in terms of patient independence. Additionally, the cut-off points separating the levels of severe and moderate disability in the functional-ADL scales BI, FIM and FAM were determined. These findings would help practitioners in poststroke clinical practice and would facilitate clinical interpretation of disability levels in different widely used assessment scales.

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Functional assessment of clinical pain in patients with chronic disorders of consciousness: a clinical approach at home treatment

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Introduction

Pain is a high incidence symptom in patients with disorders of consciousness (DOC). There is a huge number of motor and communication difficulties that can increase the possibility of underdiagnosis of pain in patients with DOCs. Otherwise, the management of pain in the chronic stage can generate controversy to clinicians and to the family. The aim of this review was to introduce a functional reasoning to assess pain treatment in the chronic stage at patient's home.

Methods

Spasticity is a positive sign of muscular hyperactivity that occurs in 88% of patients with DOCs [1], which can produce pain during assisted activity of daily living. The drug management in spasticity proves to be essential for the improvement of the sleep – wake cycles [2] which could help to improve the cognitive functioning in this patients (e.g.: attentional level) and in everyday patient mobilization itself. It cannot be forgotten that not every pain etiology is due to physical factors; cognitive and affective processing areas are activated during nociceptive stimulation [3, 4]. Other signs that most patients develop during early stages may occur due to immobility syndrome (pressure pain, joint pain) [5].

Pain management at home in chronic patients represents a problem that generates stress to the family/caregivers level as it does in the attending clinician [3]. The evaluation includes searching behavioral signs that indicate pain, or reproducing the response behavior caused by noxious stimuli [3].

Different scales can detect behavioral signs of pain in patients in minimal conscious state (MCS). The examiner must notice the different responses (facial expression, verbal response, localization of pain). Moreover, clinicians must pay attention to autonomic signs in patients at vegetative state as they can be frequently presented in basal condition [6]. The Nociception Coma Scale (NCS) [7] has proved to be a useful clinical tool due to its low inter-examiner error and the absence of differences between stages post-injury (e.g. acute/chronic stages). Chatelle et al proved that the correlation between NCS scores and the activation in the anterior cyngulate cortex due to painful stimulation were similar between healthy subjects and MCS patients [8].

The behavior of the patient with DOC must be recorded by caregivers, using a register and a clinical reasoning to improve the intervention during pain assessment (Figure 1).

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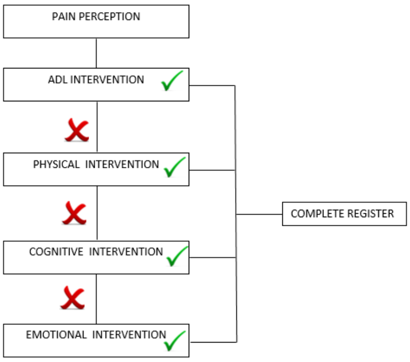

Figure 1. Pain intervention protocol

The aim of performing a register (Figure 2) is to find unknown requirements in these patients; and secondly, the increase of the knowledge of nonverbal responses. The register should include: date & hour, behavioral signs, intervention, response, and medical intervals. Caregivers must be instructed to fill in the register every day. At clinical term, this register may assess the neurobehavioral evolution [9] of the patient at medium/long term, but in any case can't replace the diagnostic done by the Coma Recovery Scale Revised [10]. We have considered that the emotional feature should be included in the clinical reasoning by the family due to the unknown level of consciousness of the patient in MCS.

Date & Hour	(dd/mm/yyyy)		
Duration	(from hh:mm to hh:mm)		
Behavioral Sign	(type, intensity)		
Contingency	Starts if		
	Ends if		
Medication Intervales	Medication: Intrathecal Pump:		

Figure 2. Register protocol.

Results

The improvement on the familiar daily intervention and the information gathering should improve the care of the patient at DOC. The evaluation of the behavior of the chronic patient may consider a non-communicative response to pain and other needs.

Conclusions

Pain and other responses should be registered to assess future interventions [9]. Regular neurobehavioral signs of the patient with DOC can help to dismiss reflexive signs [11], which can lead to confusion. The validation of this protocol and management of pain for caregivers of patient with DOC must be proved in future clinical trials.

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Effects of the rubber hand illusion experiment on stroke survivors

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Introduction

Embodiment is a multi-component psychological construct that has been defined as the sense of one's own body [1]. Recent research has focused on unifying aspects of the embodied cognition theories and on identifying its subcomponents, such as body-ownership and agency [2]. Body-ownership can be defined as the sense that the body that one inhabits is his/her own [3]. Agency refers to the sense that one can move and control his/her body [3]. Both constructs have been recently postulated as dissociated concepts [4]. The Rubber Hand Illusion (RHI) experiment has been used to study body-ownership mechanisms [4] in different conditions, mainly in phantom limb pain after amputation. However, little is known about the effects of stroke on body-ownership. The objective of this study is to determine the effects of RHI in stroke survivors in comparison with healthy individuals.

Methods

Individuals from 16 to 80 years old with no motor or cognitive impairment were included in the healthy group. Inclusion criteria for the stroke group were: 1) age ≥ 16 and < 80 years old; 2) residual hemiparesis; 3) absence of cognitive impairments (Mini-Mental State Examination [5] > 8); ability to relax the forearm and the hand and to extend the fingers on a table. Subjects were excluded in case of: 1) inability to follow instructions as defined by Mississippi Aphasia Screening Test [6] ≥ 45; 2) visual or hearing impairment that does not allow possibility of interaction; and 3) severe hemispatial neglect. A total of 34 healthy subjects (20 men and 14 women, 30.53±14.19 years old) and 15 individuals with stroke (11 men and 4 women, 52.80±13.93) were recruited. Subjects post-stroke presented hemorrhagic (n=6) and ischemic etiology (n=9).

The experiment was done in a quiet room free of distractors. A conventional table with a vertical wooden layer fixed on it was used. An experimenter sat in one side of the table. Participants sat in the opposite site, occluding one arm behind the layer. Healthy subjects occluded their non-dominant arm. Stroke survivors occluded their hemiparetic arm. Therefore, participants could not see their own arm during experimenter. A rubber hand was placed in front of the subject in an anatomically feasible position and orientation, close to the wooden layer (Figure 1).

Figure 1. Participant during the RHI experiment

Participants were asked to look at the rubber hand and “sense the rubber hand as theirs”. Then, both hands (the real and the rubber hand) were synchronously stroked with a brush during two minutes. After that time, the experimenter hit the rubber hand with a hummer, and the experiment concluded. Participants filled in a 10-item questionnaire about embodiment [7]. Items evaluated body-ownership, location, and agency, and were rated in a 7-point Likert scale.

Results

All but one of the stroke survivors (93%) reported to have owned the rubber hand, in contrast to the 67% of the participants of the healthy group. A t-test showed that this effect was statistically significant in both groups (p=0.001) (Table 1). In addition, stroke survivors reported to have felt agency over the rubber hand (p=0.003).

	Healthy group (n=34)	Stroke group (n=15)	Significance
Body-ownership	3.51±1.54	5.15±1.42	p=0.001
Localization	3.54±1.40	3.91±1.06	p=0.372
Agency	2.94±1.63	3.67±2.09	p=0.003

Table 1. Results in the RHI questionnaire.

Conclusions

The RHI experiment could evidence an alteration on the body image in hemiparetic subjects after stroke, which can promote the ownership of alien limbs. Future studies should address this hypothesis.

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Efficiency of an intervention of neuropsychology rehabilitation through robotics with traumatic brain injury in children

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Introduction

In Spain, it is estimated that, in one year, as many as 235 per 100000 persons experience a head injury. Traumatic brain injury (TBI) is a common cause of acquired disability during childhood [1].

In the last few years increased survival rates in TBI has led to an increase in child patients with cognitive consequence and they have highlighted the need to reduce the morbidity of these patients and improve their short and long-term functional outcomes. According to Anderson and Catroppa [2], children are particularly vulnerable to persistent deficits associated to TBI. TBI involves serious impact on cognitive performance and functional ability.

There is wide evidence that cognitive stimulation is beneficial for adults who have suffered TBI [3-5], however, research on the effectiveness of cognitive rehabilitation with the pediatric population remains scarce [6]. There is a lack of randomized studies evaluating the effectiveness of rehabilitation treatment in children with TBI. Nowadays, there is only one class A study that has shown good results [7].

On the other hand, since the 70s there has been an evolution in the studies on the use of computing solutions in cognitive rehabilitation. In recent years, the increased use of computers in rehabilitation centers has given rise to innovative technologies for cognitive rehabilitation like computerized rehabilitation programs, virtual reality, remote rehabilitation and robotics. Robotics is a multidisciplinary scientific tool which motivates and stimulates learning in children [8,9]. A key point of robotics is the ability to adapt to any kind of activity while being the perfect device for remote monitoring. Robots can perform therapeutic and companion functions simultaneously [10] becoming an extension of the therapist.

The aim of our study is to assess whether neuropsychological rehabilitation using robotics provides improved cognitive performance in a group of children with TBI.

Methods

Prospective and controlled study (n=26). Treatment Group (TG): n=13. Control group (CG): n=13. The TG performed neuropsychological rehabilitation for 6 months with a total of 240h (10h/week- in group).

The CG received no specific treatment. The cognitive capacity was measured (following the P. Anderson's model of executive functions) and behavioral aspects of all children in the pre and post treatment time. The design of specific activities, the validation of contents and the robots' design (hardware and software), were carried out in coordination between the two collaborating centers (Hospital Sant Joan de Deu and Universitat de la Salle).

Results

Table 1 shows that TG improved in all tests administered for him towards him. Moreover, this improvement is statistically significant in the subscript "Total movements" of the Tower of London Test (TOL) and prone to significant in the Invers Digits Test of WISC-IV and the index of externalizing behaviors of the Child Behavior Checklist. The CG however, reveals a very homogeneous profile during pre and post treatment (Table 2). It is only an improvement in the subscript "Total movements" of the TOL but without being statistically significant.

TG	n	Mean	Std. deviation	Significance	Cohen's d
spandd_pre	13	96,62	10,77	0,162	0.416[2]
spandd_post	13	101,85	7,68		
span_di_pre	13	91,00	11,97	0,069+	0,609[2]
span_di_post	13	100,38	10,38		
tol_tmov_pre	11	88,09	14,08	0,050*	0.594[2]
tol_tmov_post	13	95,46	19,38		
nepsy_inh_denom_pre	11	85,00	16,73	0,085	0,603[2]
nepsy_inh_denom_post	11	100,45	15,88		
CBCL Intern pre	13	57,38	10,59	0,456	-0.187[1]
CBCL Intern post	12	60,17	9,28		
CBCL Extern pre	13	62,46	11,79	0,065+	0.602[2]
CBCL Exter post	12	56,50	14,30		

Table 1. TG values. *: p<0.05; +: p<0.07; Cohen effect size (d di Cohen): d=0.20-0.49 (small); [2]: d=0.5-0.79 (medium); [3]: d≥0.8 (large).

CG	n	Mean	Std. deviation	Significance	Cohen's d
spandd_pre	13	101,00	14,036	0,754	-0,122[1]
spandd_post	12	98,92	20,079		
span_di_pre	13	94,54	14,321	0,929	0,083[1]
span_di_post	12	95,42	12,588		
tol_tmov_pre	12	75,92	15,791	0,062+	0.679[2]
tol_tmov_post	12	85,08	18,466		
nepsy_inh_denom_pre	13	95,00	20,207	0,341	0,294[1]
nepsy_inh_denom_post	12	100,42	12,873		
CBCL Intern pre	11	56,55	14,801	1,000	0,012[1]
CBCL Intern post	12	55,08	9,821		
CBCL Extern pre	11	53,36	9,973	0,413	0.28[1]
CBCL Exter post	12	53,42	11,229		

Table 2. CG values. *: p<0.05; +: p<0.07; Cohen effect size (d di Cohen): d=0.20-0.49 (small); [2]: d=0.5-0.79 (medium); [3]: d≥0.8 (large).

These results indicate that the TG has improved in capacity planning, in working memory and behavior problems. In contrast, the CG showed no significant change in performance over the last six months.

Conclusions

Following the P. Anderson's model of executive functions we observed that there was an improvement in two of the four areas (cognitive flexibility and goal setting) and furthermore better behaviour. These results suggest that treatment with neuropsychological robotics in this sample has been effective. It would be interesting to extend the study with a larger sample and to be able to assess their long-term effects.

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Robotic assisted gait training effect on brain cortex

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Introduction

Robotic assisted gait training (RAGT) is an intervention for rehabilitation in gait function [1]. Several studies have shown that balance, endurance, agility and strength of lower extremities improved after RAGT [2]. However the change of brain cortex activity for the improvement is not clear. Near infrared spectroscopy (NIRS) is a non-invasive approach for brain function assessment based on neurovascular coupling principle [3]. NIRS has been used to identify area of brain cortex activity during body movement [4]. In this preliminary study, NIRS was used to evaluate functional change of brain cortex in healthy participants during RAGT.

Methods

Ten healthy adults were recruited and randomly assigned to group A and B. 10-minute RAGT was implemented before and after 6-minute walking on a regular treadmill for group A and B, respectively. NIRS was measured during the two training protocols.

Results

Quantitative values of changes in oxyhemoglobin increased earlier on premotor area in group A than group B when Treadmill walking. The amplitudes of NIRS signals increased more significantly in group A than group B during treadmill walking.

Conclusions

This preliminary study shows the evidence of RAGT programing brain cortex activity for walking. However to identify RAGT facilitating central nervous system activity or neuroplasticity in the disabled, studies including different kinds of neurologic patients should be executed in the future.

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Exploring use of optokinetic chart stimulation for recovery of mobility in stroke patients: a case control series

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Introduction

Stroke is a devastating neurological disease which often leads to death, physical impairment and disability [1]. In the UK stroke care costs 8.9 billion pounds [2]. In the USA stroke costs 34.3 billion US dollars [3].

Optokinetic chart stimulation (OKCS) is a novel intervention for rehabilitation of dense acute strokes [4, 5, 6]. Optokinetic stimulation is used to treat neglect [7] and vestibular impairment [8]. The aim of this case control series is to explore differences in recovery of mobility between dense acute strokes treated by optokinetic chart stimulation and those treated conventionally.

Methods

Kent Research Ethics Committee gave favorable ethical opinion. An independent assessor measured outcomes. The mobility component of STREAM [9] was used. The OKCS based OKCSIB protocol [5, 6] was the intervention for one group and conventional physiotherapy for the other group. OKCS was carried out using an optokinetic chart designed on A4 paper. The chart was kept at a distance of 15 centimeters in front of the patient [5]. The chart consists of repeated groups of the colors of the rainbow. The chart was moved from side to side at approximately one cycle per second for 3 minutes. This was followed by moving the chart up and down for 3 minutes and then forwards and back for another 3 minutes. The patients only needed to look at the centre of the chart [5]. Conventional therapy was carried out by conventional physiotherapists who were specifically trained in the Bobath based normal movement approach.

Results

Ten patients aged between 71 and 83 years were followed up. There was no statistically significant difference between the mean ages of the two groups. Mean mobility scores were 23.6 (SD 8.17) for the OKCSIB group and 11.8 (SD 10.87) for the conventional (Conv) group. P value was 0.09 (P>0.05). There was no statistical difference between the mobility scores of the two groups. The results are presented in Figure 1.

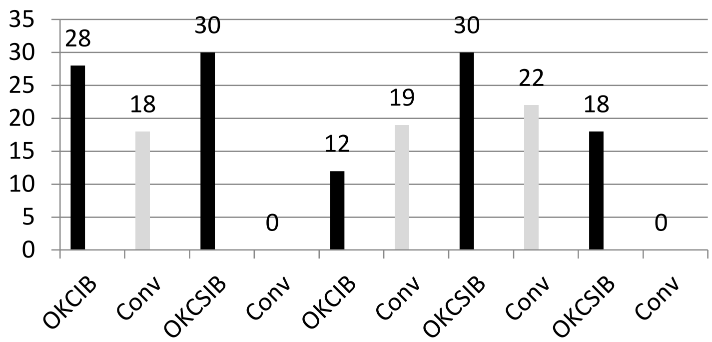

Figure 1. STREAM mobility scores

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Conclusions

None of the OKCSIB group cases completely lost mobility whereas 2 of the conventional cases completely lost mobility as shown by scores of 0/30. However there was no statistically significant difference between the mobility of the two groups. The small number of patients and the lack of randomization were the main limitations of the study. Further research is recommended.

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The effects of transcranial direct current stimulation on pain in spinal cord injured patients

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Introduction

Spinal Cord Injury (SCI) causes several health related problems affecting not only the patient's physical state, but also all aspects of his live such as mood and health-related quality of life. Pain following SCI is notably difficult to manage and often refractory to treatment. Novel treatments targeting mechanisms associated with pain maladaptive plasticity, such as neural stimulation, may be desirable [1-3]. To date few small clinical trials have assessed the effects of invasive and non-invasive nervous system stimulation on pain after SCI [4,5].

In our study we used transcranial direct current stimulation (tDCS) of the motor area (M1) on the scalp to evaluate its effects on the perception of pain in spinal cord injury patients and to determine the possible duration of pain reduction.

Methods

Double blind, randomised, single centre clinical trial. Analysis of data collected on 18 patients enrolled between August 2012 and May 2014 at the National Spinal Injury Centre, Stoke Mandeville Hospital, Aylesbury, UK, and randomly allocated to the active group or the sham group by mean of a standard randomization procedure. Table 2 summarizes the demographic and clinical characteristic at the baseline. The anodal electrode was placed over the M1 area of the dominant hemisphere, the reference electrode over the contralateral frontal area. Validated measures for pain and depression were administered during the baseline, intervention period and follow up until 1 month post stimulation. Statistical analysis was undertaken in SPSS; t-test for baseline measurements between groups and ANOVA for repeated measures and appropriate adjustments to F ratios using Huyn-Feldt corrections were used.

	Sham (n=8)	Active (n=8)	Mean difference	T statistic	P value
Age in years	39.6 (8.6)	47.8 (15.8)	-8.1	-1.280	0.221
Time from injury (months)	69.1 (103.2)	24.4 (53.3)	44.7	1.088	0.295
VAS pain (1-10)	6.4 (1.7)	5.3 (1.4)	1.1	1.400	0.183
BDI (1-63)	19.1 (13.5)	14.8 (14.9)	4.3	0.598	0.560
BRFPain severity (0-10)	6.5 (1.8)	4.5 (0.92)	2.0	2.762	0.015
BRFPain intensity (0-10)	5.6 (2.2)	3.2 (1.78)	0.8	0.616	0.550
MGPQ (0-76)	39.0 (20.4)	27.0 (15.2)	13.4	1.338	0.202
LANSS (0-24)	14.8 (5.1)	11.0 (6.4)	3.9	1.313	0.021

Table 2. Demographic and clinical characteristic at the baseline

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Results

While there were no statistically significant differences between Sham and Active groups in self-reported VAS pain, a significant effect over time was seen, but non-significant time x treatment. There was a reduction in other pain and depression figures, particularly during the treatment phase, but comparisons between groups indicated that this could be a partial placebo type effect.

Conclusions

The real efficacy of tDCS for treatment of chronic pain has not yet been proved, and from the analysis of our data, we are yet not ready to prescribe it as a treatment for chronic pain in spinal cord injured patients.

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Development of a suite of mobile applications to support communication and leisure pursuits for patients with acquired brain injury

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Introduction

The mobile era makes information more readily available. It should do so for everyone, including people with disabilities, yet accessibility is often an afterthought in device design and app development. Regardless of the sophistication of the device or the nature of the person's disability, the purpose of asssitive technology is to improve the individual's quality of life by enabling increased independence [1]. All tablet devices are first and foremost touch screens, so users need to have a degree of manual dexterity to enable access. If an individual has physical and sensory limitations they may be unable to use touch screen devices. A certain degree of cognitive and language function is also required to successfully access and operate certain apps for leisure such as radio, video clips and photo albums. A person who sustains an acquired brain injury will often experience difficulty in independently engaging in valued leisure activities due to cognitive, communication or physical deficits. For such individuals high-tech assistive technology can be used to enhance engagement in leisure activities [1,2]. Alternative methods of access for tablet devices are now being considered by mainstream manufacturers e.g. switch control functionality in ios7 for apple devices thereby enabling integration of mainstream technologies into the everyday lives of those with acquired brain injury.

The aim of this work is to outline the development of a suite of apps to support communication and leisure pursuits for people with acquired brain injury and highlight their application and use via case study.

Methods

A gap was identified in the current market for simple, accessible and age-appropriate apps that would enable adults with a variety of physical, sensory, cognitive and communication impairments due to acquired brain injury to use tablet computers for basic communication and leisure purposes. In partnership with an MSc medical device design student a suite of customisable, accessible apps was developed. Accessibility features were considered from the outset and form a core component of the suite of apps [3]. The suite of accessible apps developed encompasses the following:

- Yes/No app
- Radio
- Photo album
- Youtube playlists app

Ease of editing and customisation were key features in the development of the apps. Accessibility features include direct access, touch anywhere, and external switch access.

Results

Use of the suite of apps with patients with physical and/or cognitive impairment has shown the

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benefits of integrating technology into the assessment and treatment process of this group. Therapist and patient involvement in the development of the apps ensured that ease of set-up and customisation were to the forefront in the development process.

Key features of the app suite include:

- Individual user profile across the suite of apps
- Easy set-up and customisation of apps for users
- Reduced scanning demands for new switch users
- Potential for use as an entry level switch-based activity focussing on functional, personally relevant material (music/video/photos).

The apps allow for:

- Cause and effect training based on functional and personally meaningful activities.
- Return to valued leisure activities for patients with acquired language impairments post brain injury with increased ease of access to radio and video clips.

Creative use of this readily available, mainstream technology can offer new opportunities for assessment and treatment with a complex and diverse patient group. Case studies will be used to demonstrate specific use and functionality of the apps.

Conclusions

The simple apps have been used successfully with patients with a variety of physical, cognitive and communication impairments. Integration of simple technology into the management of patients with acquired brain injury forms a core part of best practice [1,4].

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Neurophysiological and behavioral indices of improvement after cognitive virtual rehabilitation program in stroke patients. A preliminary study

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Introduction

Cognitive impairment is common in stroke patients [1]. Specifically, the prevalence of post-stroke cognitive impairment ranges from 20% to 80% [2]. Virtual Rehabilitation (VR) systems have shown to be useful to rehabilitate balance and motor disorders in stroke patients [3], but more research is needed about possible cognitive improvement in stroke patients with this technology.

Previous studies have shown that Cognitive Event-Related Potentials (ERPs) from Electroencephalography (EEG) is a very sensible technique to assess cognitive impairment and its possible improvements after cognitive rehabilitation [4]. In this preliminary study, we applied a VR system of attentional functions in a multiuser environment, and an EEG assessment before and after 20 sessions of this VR system in stroke patients. The VR system applied proposes exercises where the patients work different aspects of attention (visual search, sustained attention, divided attention, etc...) using a competitive metaphor consisting of an Olympics, in which a score is obtained according to their performance in it. The system uses a multitouch table which captures patients' touches and transfer them to the system, facilitating the interaction.

The aim of this preliminary study was to assess possible cognitive improvements in a cohort of nine stroke patients with behavioral (reaction time and accuracy) and neurophysiological measures (latency and amplitude of the P3 ERP component), after 20 sessions of our VR system.

Methods

Nine stroke patients were recruited in the Neurorehabilitation Unit. Before the start of the VR program (20 sessions of 50 minutes each in 50 days of program), an EEG recording was applied to every patient recruited. The EEG was recorded from 58 scalp electrodes during the performance of a sustained and selective attention task (oddball paradigm) [4]. The latency and amplitude values of the P3 ERP component were calculated in the electrode that showed the maximum amplitude for each subject. Reaction times in milliseconds and accuracy were also calculated. After the program was ended, same EEG recording protocol was applied to every patient (fifty days between recording sessions). In addition, nine healthy controls were included in the study and recorded with the same EEG procedure and cognitive task in two separate sessions with the same interval between sessions.

Repeated measures ANOVA was used to analyze between groups and within group statistical differences. A Bonferroni correction was carried out in multiple comparisons post-hoc analysis. In all these analyses, a probability of $p=0.05$ was considered significant.

Group	Reaction time (ms)	Accuracy (%)	P3 latency (ms)	P3 amplitude (μV)
Healthy (Session 1)	288±15	99.0±0.7	331±24	16.7±7.4
Healthy (Session 2)	283±22	99.0±1.3	331±16	20.2±7.5
Stroke (Session 1)	371±44	80.0±26.0	421±126	8.6±5.2
Stroke (Session 2)	361±58	92.0±11.0	398±73	9.4±4.4

Table 1. Behavioral and neurophysiological results of the study.

Results

Stroke patients showed a general reaction time slowing ($F(1, 16) = 23.52$; $p < 0.001$) in both sessions recorded. After post-hoc comparisons, results showed that stroke patients benefited from VR program in their behavioral responses (10 milliseconds faster than before VR program). However, they remained slower than the healthy control group ($p=0.02$). Regarding accuracy, stroke patients showed a clear improvement (session 1= 80% of hits; session 2= 92% of hits) after VR program, but this improvement it was not statistically significant ($p= 0.27$), may be due to our small samples used (Table 1).

Moreover, P3 latency values were slower for stroke patients at the beginning of the study. In addition, healthy control group had exactly the same P3 latency in the two sessions analyzed (Session 1 = 331 milliseconds; Session 2= 331 milliseconds), but faster after VR program in stroke patients (Session 1 = 421 milliseconds; Session 2= 398 milliseconds). Lastly, regarding amplitude values of the P3, Repeated Measure ANOVA showed smaller amplitude values for stroke patients in both sessions ($F(1, 16) = 11.4$; $p =0.003$), suggesting less neural resources to process the attentional task applied for stroke patients. Interestingly, healthy controls showed a greater increase of the P3 amplitude in the second session compared to stroke patients (Table 1). This last result could suggest that neural plasticity and learning processes are impaired in the stroke patients studied, despite the VR program used.

Conclusions

Stroke patients showed behavioral and neurophysiological changes after 20 sessions of an attentional Virtual Rehabilitation program. Accuracy, reaction time and latency of the P3 component showed better scores for stroke patients after the VR program applied. However, it is recommended increase the number of VR sessions and the sample of this preliminary study to have stronger conclusions in the future.

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CogniVis: 3D visualization and navigation module of brain structures

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Introduction

The 3D visualization of brain anatomy plays an important role in the field of medical research, allowing to spatial locate anatomical structures in order to analyze them from different points of view and find the relationships between them. Several research groups have developed tools that allow three-dimensional visualization and navigation on brain models [1]. Amongst the most significant tools, 3Dslicer [2], Brain Voyager [3], and FreeSurfer [4] can be mentioned. However, to the authors' knowledge there is no a 3D visualization tool capable of working with multiple brain atlas and specifically designed both for researchers and clinicians.

In this paper we present Cognivis, a module for 3D neuroimage visualization and navigation designed and implemented as part of a national Spanish project named COGNITIO.

Methods

A knowledge capture with a group of clinical experts from Institut Guttmann was done for the implementation of Cognivis as a clinical tool. The following functional and non-functional requirements were defined:

- View and navigation on three-dimensional models generated from studies of brain medical images and brain atlas.
- Automatic segmentation of anatomical structures segmented in atlas.
- Interaction with labelled brain structures allowing to modify the colorus and visibility parameter.
- Load different atlas in the same scene to compare structures.
- Measurement algorithms to calculate area and volume of brain structures labelled.
- User-centred interface that follow standards of usability and efficiency.

Results

Cognivis provides a set of tools to visualize and analyses different brain atlases such as The LONI Probabilistic Brain Atlas (LPBA40) [5], Massachusetts General Hospital 10 Brain Atlas (MGH10) [6] or any atlas generated in a clinical or research centre. Many atlas save the information structures in XML files or text files, and Cognivis is compatible with most of them allowing users to load an atlas and automatically represent all anatomical structures labelled creating an index with all the structures from which user can select and modify the visibility and transparency of one or more labels. (See Figure 1)

Cognivis can load multiples volumes at once and overlays them in the same scene for comparison. It, also has a toolbox that allows changing the position, orientation, size and transparency of the volumes manually for easier 3D navigation. The current version of Cognivis is implemented in C++, using VTK and ITK open-source tookit.

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An initial technical validation has been performed with good results. An undergoing functional validation with end users is currently being carried out.

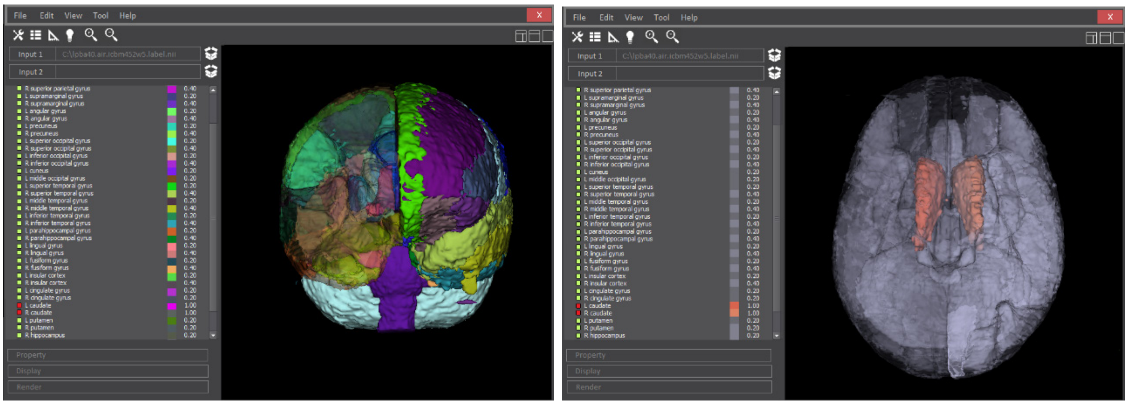

Figure 1. Cognivis user interface showing LPBA40 atlas labeling.

Conclusions

This research presents the Cognivis module, a 3D visualization and navigation tool designed for multiparametric analysis of brain, clinical data and therapy for optimization of cognitive rehabilitation in TBI. Preliminary results show that Cognivis could be a very useful tool not only for navigation by atlas but also for the identification of lesions in images of patients with acquired brain injury

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A descriptive study about functional activities and gait in patients with stroke

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Introduction

The term stroke makes reference to any neurological disorder, temporary or permanent, in one or more brain areas as a result of brain's circulation disruption [1]. The term stroke makes also reference to acute brain disease which involves generically a group of disorders which includes cerebral ischemia, intracerebral hemorrhage and subarachnoid hemorrhage [2]. In western countries brain diseases are the third cause of death followed by heart diseases and neoplasias, and it is the first cause of disability in the adult population over 65 years old [3]. In Spain, according to data published by the National Institute of Statistics, in 2012 acute stroke made up the second cause of death, being the first cause of death in women [4].

Stroke is a leading cause of long-term disability. Impairments resulting from stroke lead to persistent difficulty walking. Subsequently, to improve walking ability is one of the highest priorities for people living with a stroke [5].

The Barthel Index is an easily applicable method with a high level of reliability and validity capable of detecting changes, easy to interpret and the application of which is not problematic [6].

Functional walking has been assisted by the Massachusetts General Hospital Functional Ambulation Classification (FAC). This classification system categorizes patients according to basic motor skills necessary for functional ambulation [7]. FAC has excellent reliability, good concurrent and predictive validity, and good responsiveness in patients with hemiparesis after stroke [8].

Methods

A descriptive retrospective study has been made including all patients who were treated in Clínica San Vicente brain injury unit, who were diagnosed of stroke between January 2013 and April 2014. Those patients who stayed less than one month in our centre were excluded. There were 47 patients in the sample studied.

Analyzed variables were: age, gender, rehabilitation time, diagnosis, Barthel and FAC Scales whose data were taken at the entrance and at medical discharge. Later, Barthel and FAC scales data were collected by phone to patients who had been discharged during the time period studied, but only those who took three months off our centre. Moreover, they were asked if they had had rehabilitation after leaving our brain injury unit, and its frequency.

Results

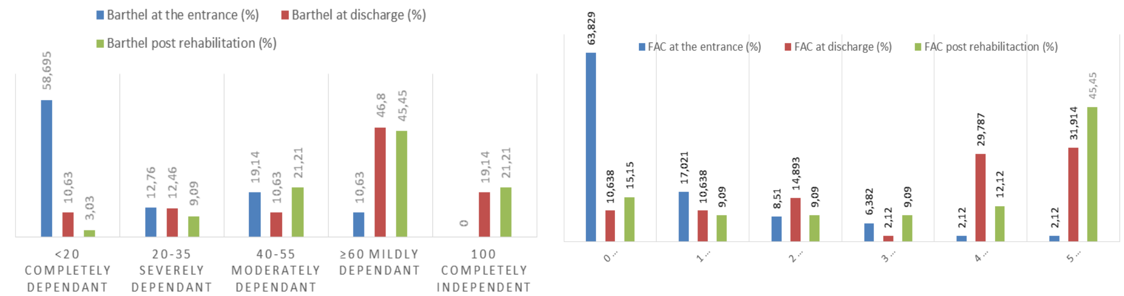
A total sample of 47 patients have been obtained over the period. The mean age was 60.36 years (SD: 11.87); 68.08% were male and 31.91% were female. The average stay of neuro rehabilitation treatment in our centre was 247 days.

Injury in right hemisphere showed 42.55% and injury in left hemispherea 57.44%. Regarding to functional evaluation, Barthel's average obtained at the entrance was 23.24 (SD:

23.84); and 66.06 (SD: 32.17) after the medical discharge. Percentage distribution it is shown on Figure 1.

In relation to FAC's results mean at the entrance was 0.72 (SD: 1.21) and 3.25 (SD: 1.76) on the date of discharge. Percentage data are shown on Figure 1.

To evaluate functional capacity and patient's gait after their stance in the centre. Those who stayed less than 3 months discharged were excluded. The number of patients who fulfilled the selection criteria was 45. Three patients of this sample died, two refused to respond and two more could not be located. The result obtained telephonically of Barthel´s average was 71, 66 (SD: 28, 63) and the result of FAC´s mean was 3, 25 (SD: 1, 64). Data is presented by percentage and they are shown on Figure 1.



a) b)

Figure 1. Results in a) Barthel Index; b) FAC.

Conclusions

After analyzing results it is concluded that more than half of patients (58.69%) hospitalized had total dependency in ADL and a high percentage (68.82%) were not able to walk or they needed help from two people. The high dependency index at the entrance could be explained by the dependency criteria used which gives priority to patients' with severe diseases who couldn´t be attended at their homes.

Following discharge, percentages are reversed. More than half (61.7%) were able to walk without technical assistance and without supervision. Moreover, most of them were able to realize ADL independently. However, within working population, only one patient has achieved job reintegration.

Disparity between rehabilitation and post-rehabilitation results may be explained by the use of phone in the post-rehabilitation test. In this way, the reliability of the results is limited, the time is not enough and the rehabilitation is inadequate.

In despite of the results from this study, new studies with an improved methodology should be done to verify outcomes of data collected and confirm the effectiveness of the different techniques.

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Effectiveness of robot-assisted gait training according to clinical severity of spinal cord injury

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Introduction

To measure the effectiveness of robot-assisted gait training (RGT) in person with motor incomplete spinal cord injury following clinical severity.

Methods

Patients with AIS C or D spinal cord injury, in the subacute stage, 1 to 6 months after injury, admitted to national rehabilitation center were enrolled. In all participants, injury mechanism of spinal cord was primary cause. Each participant was trained with Lokomat everyday for 30 minutes, maximal 5 times per week and the total training sessions were 20 times. When the participants completed total 20-session RGT, conventional physical therapy for 4 weeks was performed. Evaluation of each participant is performed to measure their motor recovery, including Fugl-meyer assessment (FMA) and lower extremity motor scale (LEMS), their physical function, including functional ambulatory scale (FAC), walking index for spinal cord injury (WISCI) and spinal cord independence measure (SCIM) and their walking capacity by 10-meter walk test (10MW). The evaluations were performed 4 times, prior to beginning of treatment, immediately after completion of session 10 and session 20 and 4-week after completion of total 20 sessions.

Results

Of the 20 participants, 6 participants were AIS C and 14 participants were AIS D. Although participants with AIS C were too small to analysis, 3 tetraplegic AIS C participants were not improved at all after RGT in contrast to those with AIS C paraplegia improving their gait function in all participants. Comparing prior to beginning of treatment with immediately after completion of session 20, 11 of 14 participants with AIS D improved their FAC score 1 point or more. Their FMA, LEMS and WISCI score showed greater improvement. 10MW was performed only 7 participants because others could not walk 10 meter independently and their score was also improved. However, their SCIM score was little improved, statistically not meaningful.

Conclusions

Likewise published other study, RGT was effective for AIS C or D patients for improving gait function. In this study, almost participants with AIS D showed greater improvement in FAC, FMA, LEMS and SCIM score than those with AIS C, though AIS C group was too small to analysis. In this manner, RGT can help patients who have motor incomplete spinal cord injury, especially AIS D type, improve their gait function.

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Haptic human-human-interaction research for human-robot-systems in motor rehabilitation

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Introduction

Robot based therapy has become a widely used therapeutic approach in stroke rehabilitation, since numerous clinical studies showed that patients can significantly benefit from robot based training [1-3]. Rehabilitation devices physically assist the patient's movement during the session and guide the hand or leg along learning trajectories so that movement errors are minimized. This technique is known as haptic guidance and is especially effective for the early phase of learning. However, according to guidance hypothesis too much feedback can harm performance improvement [4-6], whereas reduced guidance leads to better performance after training phase [7,8]. Robotic movement therapy devices with implemented “assist-as-needed” algorithms adaptively support the patient only if he cannot perform the training task independently and provides an appropriate amount of haptic assistance. Therefore, the patient's effort can be maximized and some errors may be allowed. Several assist-as-needed algorithms have been developed for rehabilitation robots [9-11] and tend to have a positive impact on patient therapy [12].

All assistance algorithms that have been developed so far were not validated with regard to haptic therapist-patient interaction, which is the reference for therapeutic intervention during rehab training. Therefore, our current research focuses the in depth investigation of haptic therapist-patient interaction, in order to derive an optimal model for haptic human-robot interaction in motor rehabilitation. To summarize previous research findings on haptic HHI we reviewed experimental psychology and interactive robotics studies. The purpose of this review is (i) to present a survey of experimental studies and research findings on haptic HHI, (ii) to detect possible benefits of haptic HHI for HRI, and in particular for motor learning and motor rehabilitation.

Methods

Publications were identified up to June 2014. Papers were collected from electronic databases - IEEE Xplore, SAGE Journals, PSYNDEX, SCOPUS, ASME DC, ACM DL, BioMed Central, PsychInfo, Web of Science and PubMed via full text search. Keywords and search algorithm: (("human-human" OR "human-machine-human" OR "human-robot-human") AND (interaction OR cooperation OR collaboration OR joint) AND (physical OR haptic OR motor)). The articles were chosen according to the following inclusion criteria: (1) the publication describes an experimental study and (2) the focus of the study is haptic HHI or human-robot-human-interaction.

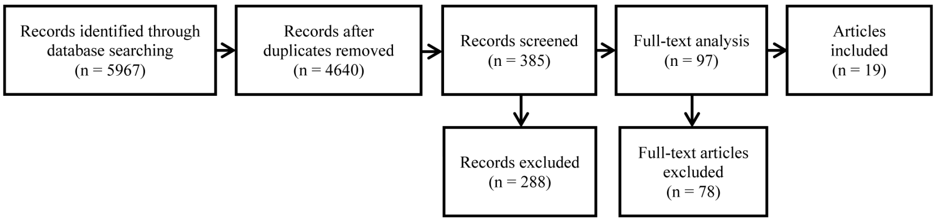

Figure 1. Identification and selection of studies.

Results

Preliminary results were presented in [13]. A total of 19 papers that meet the inclusion criteria were identified. The screening process is shown in Figure 1. A total of 5967 articles were found. After removing duplicates, 4640 publications remained, among which 4543 were excluded based on the title or abstract alone. During the full text review, 78 more articles were excluded.

As an interactive task for experiments in these studies the following were selected: crank-rotation task [14-22], moving a virtual [23-28] or real object [29-30], hand-over of object [31], wrist flexion-extension [32]. The specialization principle between interaction partners (e.g. leader/follower) was detected in 13 of 19 articles [14-19, 23, 25-27, 29-30, 32] and it was found that it leads to better performance compared with interaction without specialisation [25]. In 9 of 19 studies it was seen, that task performance in terms of completion time is better for human dyads as for individuals [14-20, 23, 28] and as for human-robot-dyads [16-17]. Two studies presented group and dyad performance in motor learning tasks in comparison with individual performance [20, 22].

Conclusions

In this review we present the results of a literature review focused on HHI. A total of 19 publications were found that matched the inclusion criteria. Only two of articles [20, 22] describe experiments about the influence of HHI on motor learning. Based on these articles it can be assumed that working in groups or dyads can be beneficial for motor learning performance for healthy individuals [20, 22]. Moreover, the individuals learning in dyads "consistently improve their performance, regardless of their partner's performance" and the improvement of performance is greater when interacting with partners which have similar motor abilities [22]. Papers, which investigated haptic HHI between patients or patient and therapist, were not identified. The review shows limited research in motor learning in cooperation between humans especially as part of motor rehabilitation. Hence further investigation in this field is required.

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Children cognitive rehabilitation program

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Introduction

Neuropsychology offers the opportunity to reconnect damaged basic processes through cognitive strategies. The intensive training may result in the reorganization of multiple levels of mental integration. Based on these statements, a partnership arose between the Laboratory of Neuropsychology and Neuropediatric Center the "ICRC PROGRAM – INTEGRATED COGNITIVE REHABILITATION CENTER". The main purpose is to assist poverty-stricken children from the public health care system, aged 0 to 16, at present risk of biological and social development disorders. Specific techniques of behavioral- cognitive intervention, as well as, intervention protocols are used to obtain a complete support of the children and care takers who part take in our program.

Methods

After a consultation at the Neuropediatric ambulatory at Clinical Hospital (CENEP-HC), children are referred for a neuropsychological assessment, which is the Children Brief Neuropsychological Assessment Protocol (CBNAP). The process detects the injured cognitive functions. Following the assessment, the results are presented on a checklist that facilitates the visualization of the areas with mild, moderate or severe decline. Following, there is an interview with the parents, who along with the schools professionals receive all the orientations about the practical interventions that must be put in practice. The medical staff explains the results, and refers to the ICRC PROGRAM. The criteria of inclusion is the age and the level of the deficit shown by the assessment. The program staff meet monthly to evaluate the development of each child and for family orientations. The patients placed in the program participate in weekly workshops of pottery, painting, wood art, paper art, chess, recycled materials, video games, cooking, memory, and logic activities. There they develop cognitive functions such as attention, concentration, memory, logic, executive function, reasoning, visual perception, sensations, visual-motor ability e motor-coordination. Two procedures in the behavioral-cognitive intervention are being developed and administrated for the caretakers and their children who are at biological and social risk. The first procedure is the elaboration of a computerized evaluation of the infant's development, which will help identify early on learning disorders and deficits. Caregivers will be able to answer themselves the behavioral inventory about the child in their care and receive the classification of the level of development of the infant. The data collected by the computerized inventory generates a longitudinal research of the subject, which partakes in the two experimental groups. The second procedure is the elaboration of an individualized digital portfolio of each child, which will be accessible online by teachers and parents.

Results

Currently, the project is in its initial phase of method application. This work is characterized by a longitudinal case study of case-control that has been carried out with a sample of n: 30 subjects. During 18 weeks, the experimental group was exposed to stimulation of activities during participation in the rehabilitation project. The results did not suggest a significant difference between groups, yet, neither did they show difference in comparison of subjects from the experimental group, at the beginning and end of the study. However, the qualitative analysis performed from the descriptive results allowed to observe improvement in the responses of the experimental group

Conclusions

The objective is to improve the preserved aspects of their cognitive functions, help them achieve quality of life in their own contexts and minimize the academic failure. It is important to highlight that this population can become productive, considering their limitations and cognitive deficits, by attending a rehabilitation program. The ICRC program provides opportunity for this population to become active citizens within their society, and not just another costly individual to the public health care system.

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Parental intervention in neuropsychological rehabilitation of Brazilian children at social or biological risk

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Introduction

Development of strategies and implementation of parental intervention material in neuropsychological child rehabilitation program with Brazilian children at social and / or biological risk.

Methods

The sample is composed by children, parents, caregivers and teachers who are weekly attended by the Attention Integrated Program of the Neuropsychological Development of Children and Adolescents (APNDCA), in which our child neuropsychological rehabilitation university project takes place in Applied Psychology Center of Federal University of Paraná- Brazil. The project began with a literature review, aiming the theoretical foundation based on international strategies of cognitive rehabilitation. Adjustments to poverty indicators were necessary in order to adapt the methods and be able to target the specific group of undeveloped third world population. The instruments used in this project are the Parental Intervention Model (PIM), Development Scales like Portage, Bayley Scales of Infants and Toddler Development, Third Edition and WISC-IV. The psychological and educational orientations compose the parental intervention material and one folder for each child. This preliminary research is a longitudinal experimental study in which, after the first cognitive evaluation of the children and the families, two groups were formed: GA - experimental group of the parents and caregivers submitted to the PIM and, GB - control group of the parents and caregivers not subject to the PIM. The research evaluates the cognitive progress of each child by using the Children's Brief Neuropsychological Assessment Protocol (CBNAP) that is composed by WISC-IV, Mental Maturity Scale Columbia, CBCL, and executive function, memory and language tests. The children of GA and GB are being twice a year assessed, every six months. Parents and caregivers submitted to PIM, are compared with the control group that did not use the parental program. Both investigations will be analyzed in order to present initial results. Registration on BANPESQ / THALES: 2015017217.

Results

Currently the Project is being put in practice its experimental version. With approximately 20 children and their families being submitted to the program. All of the children were evaluated by an elaborate neuropsychological evaluation protocol and also submitted to distinct protocols.

Conclusions

The work process of cognitive rehabilitation of children with biological or social risk requires the fundamental use of precise and effective instruments, applied with the parents or caregiver of this specific population for an optimal and complete rehabilitation of the child and its social context.

The influence of a limited ability of peripheral nerves to adapt to movements with patients after central lesions

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Introduction

The most common situation during our daily life activities is moving far out of the resistances of our body. Only during sport activities or during intensive training sessions we are working on purpose in our limits.

Muscles activity is known to be optimal in their midrange position. If a joint is mobile, the muscle can generate strength in a wider range. If there is a restriction of the mobility, strength will not develop as much as it would do under normal circumstances. Also if the muscle is weak it would be less ready to counteract resistances.

Resistances might be caused by individual ranges of joint mobility, due to the general training situation, the genetic predisposition or joint problems. Other reasons for restrictions within the body are scars in different layers of connective tissues, inelastic fascias and neural structures that have lost their ability to adapt to movements [1].

Our clinical findings concerning movement after a lesion to the CNS (Central Nervous System) lead us to underline the importance of the knowledge about the structural alterations that come with inmobility and how it affects the PNS (Peripheral Nervous System) as the pathway for afferent and efferent information, not only referring to movement but also to perception, body representation in the brain and sensitive an motor aspects, that all together define the way a human being moves.

Methods

That nerves are gliding, sliding, unfolding and therefore adapting to any kind of movement has been proven by several authors, first in animals and cadavers, later with ultrasound in people without and with nerve gliding problems such as carpal tunnel syndrome [2-4]. This idea has been taken up by other authors to prove and adapt it to people after lesions to their CNS, like upper motor neuron lesions, cerebral palsy and tetraplegia [1, 5].

Typical movement disorders after central lesions were clinically analized using the knowledge of the positions of neural tests. It appeared, that these movement patterns, often called spastic patterns, are, to a greater or lesser exent, unloaded positions for the peripheral nerves [5].

First trials with ultrasound images on patients after a stroke have shown that the peripheral nerves are squeezed in their mechanical interface, mainly from hypertone muscles and static positions that reduce nerve gliding. Current literature on orthopaedic problems evidence that if a nerve is mechanically altered, the impulse transport within will be altered as well [2,6].

This may lead us to think that the restricted ability of peripheral neural structures to adapt to movements can cause high resistance as well. It might be the mechanical stress, the mental stress to painful or fearful experiences because of the expectance of being moved, or a combination of both. Therefore a precise examination of mechanical limitations of peripheral

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neural structures is inevitable for any treatment approach, focusing on movement disturbances after a lesion to the CNS [5].

Results

All the research available on the understanding of the PNS would suggest that some of the clinical findings in people with neurological disorders can be explained as a result of peripheral nerves not being moved sufficiently.

Also, we can clinically observe that the reduction in movement quality when a movement has to be done in a neural preloading condition is precisely what we see when patients after central lesions are performing an activity [7].

Conclusions

The research interpretation show that overcoming neural limitations never means stretching [8,9]. In case of a painful restriction, the first choice would be techniques to slide the nerves within the body [10]. If it is primarily a problem of stiffness / rigidity of the connective tissues around the nerve and within the nerve layers, the focus would be on regaining range rather than on sliding, being aware that the more acute the situation is, the higher the mechanosensitivity within the nervous system will be [6,8,9].

To keep the new gained range after the mobilization, selective muscle control is necessary, as it prevents nerves from too much pressure or pulling [11-13]. If a patient after a central lesion has deficits in muscle control, the mobilization can be done only in a passive way, but the effect will be less permanent . Therefore muscle work has to be trained as early as possible, always respecting the neural position in which it is done because muscle strength and selectivity will develop faster in neural unloaded positions.

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Robot-assisted upper limb therapy in children

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Introduction

Robotic therapy is a relatively new method of treating children with cerebral palsy [1]. We investigate the application potentials and effects of robot-assisted upper limb therapy in children with cerebral palsy or acquired brain injury.

Methods

A retrospective chart review of children who had received robot-assisted upper limb therapy from September 2013 to June 2014 was performed. The identified variables included diagnosis, gender, age, and duration of onset, Manual Muscle Test (MMT) and Modified Ashworth Scale (MAS) of upper limb, Fugl-Meyer Assessment (FMA), Modified Barthel Index (MBI), number of sessions completed, and the reason for treatment discontinuation. Robot-assisted upper limb therapy with the InMotion2 robot (Interactive Motion Technologies, Inc., Watertown, MA, USA) was provided during 30 minute session, 5 times per week, for 4 weeks. Children were seated comfortably at the robot workstation and asked to perform 640 repetitive, goal-directed planar reaching movements with the paretic arm during each therapy session [2]. Changes in FMA, MBI, MMT and MAS values of upper limb before and after therapy were verified.

Results

A total of 8 subjects (3 with cerebral palsy and 5 with acquired brain injury) received robot-assisted upper limb therapy; of them, 5 subjects (62.5%) completed the 20 sessions. Of the 3 subjects who did not complete the 20 session, a 9-years-old subject with hemiplegia due to Moyamoya disease was transferred to another hospital for scheduled operation, while the other 2 subjects (5 years old with cerebral palsy) were discontinued for difficulty application due to short arm length and difficulty concentrating. Of the 5 subjects (mean age, 9.4 years; 3 boys and 2 girls) who completed the robot-assisted upper limb therapy, 4 had acquired brain injury (mean duration of onset, 12.7 months) and 1 had cerebral palsy. The 5 subjects showed no changes in MMT, MAS after therapy; however, their F-M assessment and MBI scores improved an average of 4.8 and 13 points. In particular, FMA showed improvements in the order of upper extremity, hand, coordination/speed, and wrist subscore of 1.6, 1.6, 1.2, and 0.4 points, respectively.

Conclusions

Improvements in upper-limb function and coordination in children can be anticipated after robot -assisted upper limb therapy. This therapy can apply to most children with appropriate arm's length and attention. Additional future studies on subject selection and protocol are needed to maximize the effect of robot-assisted upper limb therapy in children.

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Novel trunk training device for patients early post stroke

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Introduction

Stroke is associated with a high socio-economic burden on individuals and healthcare systems, responsible for an annually worldwide loss of 72 million disability-adjusted life years [1-3]. Nearly half of stroke survivors are left with disabilities making them dependent on others for activities of daily living [1, 4]. Evidence demonstrates that improved sitting balance and trunk control is of major importance for motor and functional outcome [5, 6]. Literature shows that sitting balance rehabilitation on an unstable seat (exercise ball) is superior to conventional rehabilitation, with an important carry-over effect towards functional balance during standing and walking [7]. However, the usage of exercise balls in therapy is limited by lack of security and non-adaptable instability.

The aim of this project is therefore to develop a novel rehabilitation device (T-CHAIR) with adjustable instability and physiological motion pattern to improve trunk stability, mobility and balance early post stroke.

Methods

In a first step of the patient-centered T-CHAIR development, six key elements were identified: 1) Adjustable instability to adapt difficulty level to patients need; 2) Natural motion to increase carry-over effects of the therapy; 3) Two function mode (active and passive) to use the device with patients of various severity; 4) Ensure patient safety without the need of the therapist; 5) Ease-of-use of the whole device in clinical setting; 6) Simple and direct integration into existing therapy approaches.

Despite the instability, the patient must be able to hold a stable position of head and upper body to not overwhelm the vestibular system. To define constructional requirements for the instability and mobility of the seat, the natural kinematics of the upper body in free sitting was therefore analyzed in 27 healthy subjects and defined as target motion. Derived from this study, the T-CHAIR was developed and human upper body kinematics while sitting on the T-CHAIR was compared to the target motion and walking with an additional 30 subjects. The T-CHAIR was afterwards equipped with a motor to assist mobility and instability for severely affected patients. Patient's safety and ease-of-use requirements were elaborated with therapists and patients and verified in two preclinical trials with eight stroke patients of various severities. Requirements for integration into existing clinical treatment approaches were developed in expert interviews with leading European clinicians.

Results

The analysis of the natural upper body motion informed the development of the novel chair mechanism and enabled the adjustable instability in medio-lateral direction. Laboratory studies showed similar motion behavior while sitting on the T-CHAIR compared to free upper body motion and walking (Figure 1). The position of the head and thorax was not affected by the

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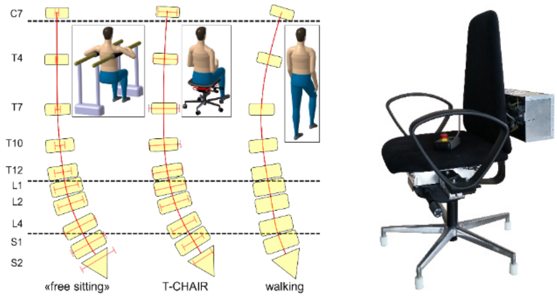
mobility of the seat (motion less than 0.2° and 0.5cm) despite a considerable lateral flexion of the spine (8.5°). The instability of the active T-CHAIR (with DC motor equipped, Figure 1) can be controlled by adjusting movement speed and range, the instability of the passive T-CHAIR is controlled by tension springs. Results of the preclinical trials showed a very high level of interest of patients and therapists in both, the active and passive T-CHAIR. The elaborated safety arrangements were described as useful and sufficient for the performed therapies. There were no problems regarding ease-of-use observed and reported, neither on the part of the therapists nor by the patients. The simple and direct integration of the novel therapy device into existing treatment approaches is ensured according to clinicians' opinion.



a) b)

Figure 1. a) Spinal motion on the T-CHAIR (8.5° in total) compared to natural spinal motion of free sitting (7.5°) and walking (9.0°, [8, 9]); b) Active T-CHAIR used for preclinical study.

Conclusions

The ability to stand upright is often restricted by impaired motor control of the trunk. Correspondingly, balance training must start while sitting before it advances to standing. The T-CHAIR introduces a completely novel therapy that may be used with various balance impaired patients not limited to stroke (e.g. traumatic brain or spinal cord injuries). Since lateral sitting balance is more affected by stroke than anterior-posterior balance [10], lateral instability was first implemented, but next preclinical trials will be performed using a novel T-CHAIR with additional instability in anterior-posterior direction, creating a unique 3-D spatial motion. However, the large range of functional limitations of the patients makes it necessary to install additional safety equipment (e.g. harness, lateral support). Additionally, the motor-driven motion (active T-CHAIR) shall be controlled via a simple touchscreen interface instead of hardware buttons.

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A low-cost posturography assessment using the Wii Balance Board. Reliability and clinical utility

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Introduction

Posturography systems incorporate force plates to objectively measure balance and postural control while assessing sensory integration. The Nintendo Wii Balance Board (WBB) is an inexpensive and portable force platform that has proved to have similar performance to those used in laboratory grade posturography systems [1]. We have developed a web-based tool that would create a clinical posturography system based on the WBB [2]. The aim of this study was to determine the psychometric properties of this experimental assessment tool and to characterize a cohort of stroke individuals with respect to a sample of age-marched healthy subjects.

Methods

A total of 144 healthy individuals (43.34±18.59 years old) and 53 individuals with stroke (52.11±13.70 years old) were enrolled in this study. Individuals with stroke presented with ischemic (n=24) or hemorrhagic (n=29) etiology, and chronicity of 788.75±692.15 days. Inclusion criteria were ability to stand unassisted for 30 seconds and to understand instructions (Mini-Mental State Examination [3]>23). Subjects with severe aphasia (Mississippi Aphasia Screening Test [4]<45), arthritic or orthopedic conditions affecting the lower limbs, or severe hemispatial neglect were excluded.

All participants were assessed on the WBB-based system, which consisted of three standardized posturography tests: the modified Clinical Test of Sensory Interaction on Balance (mCTSIB), the Limits of Stability, and the Rhythmic Weight Shift. Performance of individuals with stroke was compared to that of healthy subjects and classified in each test as not altered, mildly altered, or severely altered. To determine concurrent validity of WBB-based posturography, individuals with stroke were also assessed within 5 days with the laboratory grade NedSVE/IBV posturography system (IBV, Spain), and with a battery of standardized clinical scales. A group of 10 subjects were assessed twice in the same day by the same physical therapist and another 10 subjects by two different physical therapists to determine intra and inter-rater reliability, respectively, using the intra-class correlation coefficient (ICC).

Results

Measures from the WBB-based system successfully ranked individuals with stroke according to severity of their symptoms, thus characterizing them in comparison to a healthy population. The system demonstrated high to excellent concurrent validity with the NedSVE/IBV system for velocity of COP motion during the mCTSIB ($r=0.911$, $p<0.01$). Responses to other clinical scales trended in the expected direction, but correlations with WBB results were not strong. All measures other than directional control exhibited excellent inter- and intra-rater reliability ($ICC>0.8$, $p<0.01$).

Conclusions

Comparison of a WBB-based posturography system to a commercially available posturography system suggests that this more economic, freely available system can be relied upon to assess changes in the balance abilities of individuals following a stroke.

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Effect of a guided joystick on input value accuracy during joystick control

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Introduction

People with disabilities often use joystick as an input device for computerized clinical evaluation tools. However, the disabled sometimes make mistakes in moving a joystick in their intended direction when the direction of joystick movement is not guided. The aim of this study was to compare joystick input accuracy between stroke patients and normal subjects and also to look at the effect of adding a guiding slit to joystick to help people with stroke move the joystick in the intended direction on improving joystick response accuracy.

Methods

The study was conducted in an experimental room in Korea National Rehabilitation Center (KNRC). 21 stroke patients (Male 20, Female 7) and 18 subjects (Male 5, Female 13) participated in this study. Participants performed a task in which they moved the joystick input device in three directions (upward, left, and right) with or without the guiding slit in random order.

The research equipment consisted of a joystick input program, an unguided joystick, and a guided joystick (Figure 1).

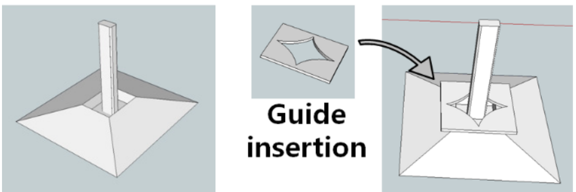

Figure 1. Unguided and guided joysticks

The main outcome measures were error values in each joystick direction (i.e., right error value, left error value, upward error value). Each joystick input was made every 2 second and the total input time for each direction was 20 second, for 10 times.

The error values from the correct input direction were recorded and analyzed according to the subject's group and guide insertion. Paired t-test (guided joystick vs unguided joystick) and independent t-test (stroke vs healthy) were performed considering $p<0.05$.

Results

Table 1 shows that significantly less errors were made in all three directions when the stroke patient used the guided joystick compared to when they used the unguided joystick.

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	Direction	Unguided (error value)	Guided (error value)	P-value
Stroke	Left	288.82±296.19	2.01±9.16	0.000**
	Right	180.86±222.58	28.64±55.10	0.002**
	Upward	107.39±177.93	2.57±7.74	0.005**
Healthy	Left	20.48±49.08	0.77±3.29	0.110
	Right	7.34±17.61	5.46±23.15	0.796
	Upward	2.99±10.63	3.26±10.08	0.921

Table 1. Result of error value according to the guide insertion.*: $p<0.05$; **: $p<0.01$.

Table 2 shows that stroke patients made more errors in manipulating the joystick than normal subjects. However there was no significant difference in errors between the two groups when the guided joystick was used.

	Direction	Unguided (error value)	Guided (error value)	P-value
Stroke	Left	288.82±296.19	20.48±49.08	0.000**
	Right	180.86±222.58	7.34±17.61	0.002**
	Upward	107.39±177.93	2.99±10.63	0.017*
Healthy	Left	2.01±9.16	0.77±3.29	0.585
	Right	28.64±55.10	5.46±23.15	0.099
	Upward	2.57±7.74	3.26±10.08	0.795

Table 2. Result of error value according to the subject group.*: $p<0.05$; **: $p<0.01$.

Conclusions

In conclusion, stroke patients showed lower accuracy of joystick manipulation compared to normal subjects. However the errors were significantly reduced by using the guided joystick. Therefore, when the stroke patients use an input device such as joystick, we recommend to insert guiding slit.

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Adaptation of the Nociception Coma Scale – Revised for integration in the daily routine of a post-comatose patients care unit

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Introduction

It is admitted that patients with disorders of consciousness (DOCs) have a cortical processing of pain [1] and that, at least for MCS (Minimally conscious state), they have a cortical integration of nociceptive stimuli quite similar to conscious people [2]. It suggests that they can feel the pain but until recently, there were too few tools to assess it objectively. The Nociception Coma Scale in its revised version (NCS-R) developed by Chatelle et al., is a sensitive and validated scale [3] that tries to answer this problem. In our post-comatose patients care unit, we tried to use it on a daily basis but we were quickly faced to a lack of adequacy to the daily routine. We decided to create an adaptation of the scale to fit better to this aim in order to use it in a more systematic way.

Methods

NCS-R has been used in our post-comatose patients care unit for 5 months on 11 patients DOCs. Previously, nursing team had a training session performed by C.Chatelle in late 2013. At early stage, the use was only sporadic and we were faced to the need of a tool that fits better to the daily routine. A first adaptation of the scale was designed, in which one had to define the condition of assessment and the follow-up if score was higher than 4 (set as the threshold for pain in NCS-R [3]).
After this first phase, we made a session of sensitization for the nursing team and developed a new version of the adapted scale, as we also had to adapt it to the electronic health record. In this new version (Figure 1.a), we reworked the condition of assessment and the subsequent actions (Figure 1.b). We also added the "subjective impression of anxiety" item.

NCS-R– Evaluation sheet				
Patient :	**Date :**			
	Heure :			
Motor Response				
3 – Localization to noxious stimulation				
2 - Flexion withdrawal				
1 – Abnormal posturing				
0 – None/flaccid				
Verbal Response				
3 – Intelligible verbalisation				
2 - Vocalisation				
1 – Groaning				
0 – None				
Facial expression				
3 – Cry				
2 - Grimace				
1 – Oral reflexive movement/startle response				
0 – None				
Total score (Threshold set to 4)		9	9	9
Condition				
Subjective impression of anxiety (*)				
Action				
Signature				

a)

Action	**/**	No specific action – Reassuring patient
	PRN	Administration of medication as needed
	INI	Independent nursing interventions
	R/PRN	Medical prescription of PRN medication
	R/	Prescription of daily medication/painkiller

Condition	**R** - Resting	**TC** - Tracheostomy care
	T - Transfer / reinstallation	**B** - Bath
	S - Skin integrity (every situation involving it as wound care/injection i.e.	
	Mobilizations	
	ULM L/R - Upper Limb Mob	**LLM L/R** - Lower Limb Mob **L/R**
	LD L/R - Lat Decubitus **L/R**	**O** - Other

b)

Figure 1. a) NCS-R - Evaluation sheet (original A4 version with 18 evaluations possible on a sheet). b) List of actions and conditions available to fill evaluation sheet.

Results

Before the second adaptation of the scale, the mean of daily assessments was only 1.05 by patient for a mean of 4.22 patients in the care unit. At that time, we noticed that 41.78% of assessments were made during complete bed bath. Consequently, there was a lack in identifying the exact painful stimulus.

After sensitization of the team and creation of the new adapted version, we got a more systematic use as the mean of daily assessments was 2.22 (increase of 117%) by patient for a mean of 4.01 patients at a time.

"Complete bed bath" item was split up in its different components, resulting in a more precise definition of the nociceptive stimulus. No data is available for comparison because of the use of items in other conditions than complete bed bath. Unfortunately, there was also a lack of precision or wrong annotation of the condition in 18.28% of the assessments.

Conclusions

The integration of the NCS-R in the daily routine of a post-comatose patient care unit has not been reported yet to our knowledge, although it has already been used in an intensive care unit [4]. NCS-R is an easy to use, valid and reliable tool [3], but there was a need of an adapted version of it to fit to the daily practice. With this adapted version and the use of electronic recording, the use of the scale and the description of the condition of assessment got and will get more systematic and precise. This will help in anticipating potentially noxious stimuli and get more efficient in the management of pain.

The item "subjective impression of anxiety", for lack of anything better until now, should be integrated in this adapted version of the scale, as anticipation of pain seems also a challenge in daily practice. A study of efficacy will be undertaken in the future. Before that, a flowchart for a reasoned use of the scale has been created in our center and will be assessed in the next months.

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The positive effect of BTX-A injection combined with serial castings in a gait pattern in a child with spastic cerebral palsy

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Introduction

Equinus foot is a musculoskeletal complication ant it is the most common problem in ambulatory children with spastic cerebral palsy (CP), which results in an unstable and inefficient gait pattern and may cause limitation of activities such as the walking function. Botulinum toxin type A injection has been considered an effective therapeutic approach. Reduction of tone and an increase in ROM (range of motion) at the ankle joint and an improvement of gait pattern. Casting in children with CP has been used to increase ROM through this physiological adaptation to prolonged stretching.

While in some studies combined therapy resulted in better outcomes than those with only BTX-A, others conclude that the use of serial casting as a unique therapy has better results.

Methods

A 6-year old girl with cerebral palsy, level 3 in the GMFCS scale with equinus gait, who has received botulinum toxin treatment combined with serial castings, participated in the study. The girl first received 8 shots of botulinum toxin in the following muscle groups: (2 adductor muscles, 2 biceps femoris, 2 gastrocnemius of both lower limbs). A month after that treatment, when the botulinum toxin's effect was at its peak, the casting of lower limbs was started, either one or both, depending on the shortening assessed at that moment. The girl is laid in prone position with the knee flexed to 90º and the ankle dorsiflexed to maximum attainable dorsiflexion for put the serial casting.

Every week the casting is taken off, the ranges of motion are measured and, depending on the evolution, a new casting may be done; this process could be repeated a maximum of three times. Then we recorded the results and compared them with the starting point to assess ROM changes.

Results

The results attained in the first stage are shown below (Table 1). There was an increased range of motion of both knees, in the soleus and the gastrocnemius after 3 weeks of serial castings. 3 months after the first treatment the knee's range of motion was reassessed, with a worse result than after the serial casting but still better than before the treatment. The results attained in the second stage are shown below (Table 1). There was, after a week of serial casting, positive changes in the right ankle's range of motion, but the treatment was stopped due to a reddening of the instep. The left foot received no treatment given that the ranges of motion were within normal gait patterns.

	July 2014		March 2015	
	Left	Right	Left	Right
Soleus before serial castings	0º	0º	+25º	+10º
Soleus after serial castings	+25º	+25º	-	+25º
Gastrocnemius before serial castings	-5º	-5º	+5º	0º
Gastrocnemius after serial castings	+5º	0º	-	+10º

Table 1. Results serial casting

Conclusions

The combination of botulinum toxin shot and serial castings show a positive impact on the gait pattern, increasing the stretching ability of the muscles being treated (soleus and Gastrocnemius) and consequently allowing a better heel strike while walking

The study also shows that the positive effect progressively disappears in the ensuing months lasting, according to published research, a maximum of 6 months. We must be concerned about potentially adverse effects, like, in our case, skin injury.

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Virtual reality rehabilitation for patients with spatial neglect. A case study

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Introduction

After brain lesions some patients show a reduced response to stimuli contra lateral to the lesion due to spatial neglect, in some cases without sensory loss [1]. As the condition is not well understood and some patients are not aware of their impairment, diagnostics is difficult and successful therapies are sparse. Here we investigate the possibility to use the Rehabilitation Gaming System (RGS), a Virtual Reality (VR) rehabilitation tool, for spatial neglect diagnostics and rehabilitation. The beneficial effects of RGS in upper limb recovery has been shown in previous studies [2,3]. Here we address the question whether the principles underlying RGS could be useful to diagnose and treat spatial neglect. We hypothesize that by encouraging to explore the neglected side with the paretic arm, the perception of the neglected side would be restored in an action oriented bottom-up approach [4]. By analyzing two case studies, we identify the potential and challenges of action oriented VR based rehabilitation and diagnosis offered by RGS with emphasis in inter-patient variability and the need for the individualization of therapy.

Methods

Two chronic right hemisphere stroke patients (24 months post stroke), with and without neglect, underwent 6 weeks of daily training sessions with RGS. One session consisted of three different rehabilitation training protocols that treat motor deficits [5]. Training was presented through RGS. Its set up consists of a desktop touch screen computer (56 x 8.2 x 40.4 cm, HP, US) for displaying the training scenario and a Kinect motion capture system (Microsoft, US) for tracking the movements of the patient. The movement was mapped onto an avatar in first person perspective using Unity3D. By moving their arms accordingly, the patients had to touch targets in the virtual world that would appear randomly in the paretic (left) or non-paretic (right) workspace in front of them. This forced them to constantly observe both sides of the workspace. The patient's abilities were tested weekly in a real world scenario, where the patient had to physically touch randomly appearing dots that were projected on a table.

	CAHAI		Fugl-Meyer		Barthel	
	Baseline	End	Baseline	End	Baseline	End
Patient 1	7	7	16	29	48	48
Patient 2	45	45	43	51	95	95

Table 1. Clinical scales. Before and after the training period, the progress of neglect patient 1 and non-neglect patient 2 was measured through clinical scales.

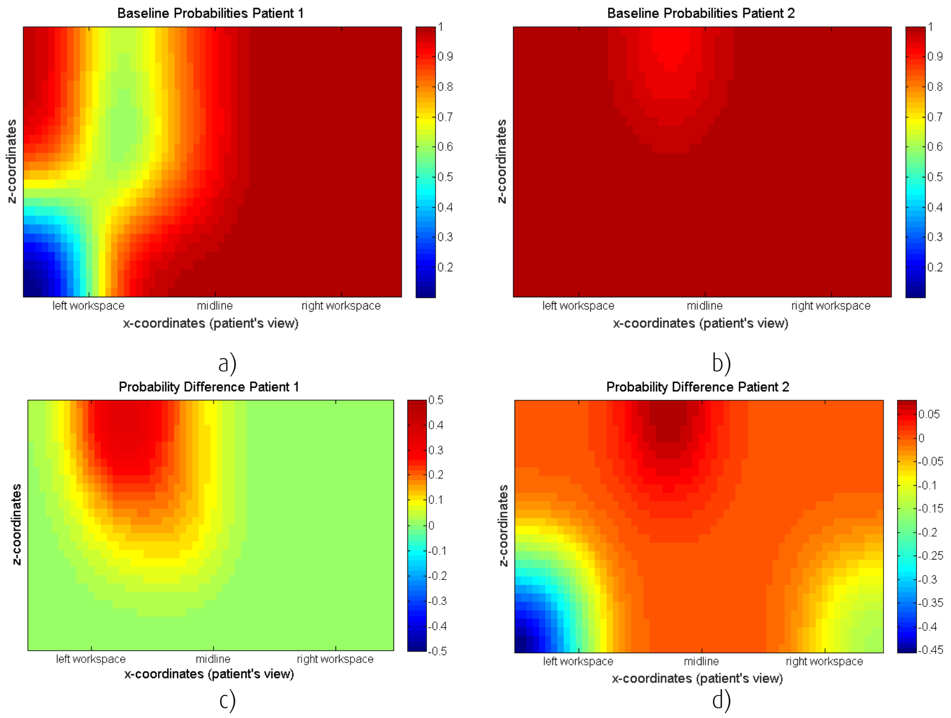

Figure 1. Real world workspace. Baseline probabilities (a and b) and probability difference between the first two and last two sessions (mean, c and d) to reach for targets in the real world workspace with the paretic arm, for neglect patient 1 (left panel) and non-neglect patient 2 (right panel).

Results

According to the outcome of the clinical scales (Table 1) both patients show motor recovery but not functional recovery of arm and hand or in the activities of daily living. In order to understand these results, we looked at the change in probability of directing the hand to targets in the real world scenario, when only the use of the paretic arm was allowed (Figure 1). We divided the workspace into 3x6 clusters and applied a Gaussian kernel filter with standard deviation of 5 in order to obtain the heat maps. When we compare the baselines of the two patients, we see that the neglect patient had a worse initial reaching probability than the non-neglect patient, concentrated in the neglected side. Looking at the difference between the baseline and the last two sessions, we see that he improved his probabilities, mainly in the front region of the neglected side. This is almost the same area of improvement for the non-neglect patient. Interestingly, only in this area he also showed low probabilities in the baseline. This suggests that the training transferred to the real world workspace of the neglected side, which might have contributed to the motor recovery, but not the functional outcome. This approach helped us, to gain insight into the patient’s improvement and allocate it to specific areas in their workspace that could be potentially targeted in a specific treatment.

Conclusions

We have addressed the question whether RGS could be useful to diagnose and treat spatial neglect. Our data shows that we can identify the neglected areas and that patients show improvements to reach targets in their neglected workspace. We have observed that changes in neglect related performance are autonomous of changes in functional motor recovery, suggesting that the underlying mechanisms are independent and possibly sequentially coupled, i.e. functional recovery requires first a reorganization of the systems underlying neglect followed

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by motor recovery. The patient should therefore be made aware of his whole work area, which could improve the perception of the otherwise neglected visual workspace. Through encouragement to execute and observe actions in the neglected workspace, he might reestablish the link between perception and action. RGS integrates both steps and could target specifically the neglected spots identified in the patient.

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Physiotherapy for pusher behaviour in a patient with stroke: case report

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Introduction

The pusher syndrome was first described in 1985 by P. Davies [1]. It was defined as a patient who actively "pushed" with their non-affected extremities towards their most affected side, presenting a strong resistance to the attempts of the therapist to bring them to a vertical position. When it was first described it was associated with other alternations such as heminegligence, anosognosia, apraxia and aphasia, encompassing what became known as "pusher syndrome". It has now been shown that it is not always associated with these alternations, therefore, it is no longer called "syndrome" in the literature, but simply given the name of "pusher behaviour".

It is estimated that approximately 10% of patients who suffer a stroke may develop these symptoms [2]. The causes that lead patients to behave in this way are still unknown although it is suspected that it relates to a deviation from their midline and an alteration in the sensation that their body has in "maintaining itself upright" [3,4]. It seems that it is the SPV (subjective postural vertical) and not the SVV (subjective visual vertical) [5], which is affected in these patients therefore some authors proposed a treatment that consisted of introducing visual stimuli [6]. However, it has been shown that patients with heminegligence do have the SVV affected, due to the fact that a lot of the patients who have this pusher behavior also present with heminegligence, the effectiveness of this method can be questioned. Therefore, a case of a patient who was successfully treated without these visual stimuli was presented.

Methods

This is a 46-year-old patient with an intraparenchymal hematoma who was admitted to our unit to receive rehabilitation treatment. In the initial assessment he showed signs that, based on what Davies[1]said, lead us to believe that he may be a pusher patient. He was assessed with the Burke Lateropulsion Scale (BLS) [7] and the Scale for Contraversive Pushing (SCP) [8], which are used specifically to diagnose this alteration, and he achieved a maximum score on both scales. Moreover, given his postural alteration, the Barthel Index was used to find out his functional dependence.

The patient received daily physical therapy from Monday to Friday, with each session lasting 45 minutes. Treatment consisted of approaching the patient from the non-affected side, shifting the weight towards his least affected pelvis and lengthening the shortened trunk by functional activities and premature standing.

The patient was assessed every 10 sessions using two pusher patient scales and the Barthel scale.

Number of sessions	Session 0	Session 10	Session 20	Session 30
SCP	6	5.5	3.5	0.25
BLS	16	14	10	0
Barthel Index	0	0	5	5

Table 1. Results

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Results

The patient received a total of 30 physiotherapy sessions until a total reduction in pushing signs according to the two scales was obtained. In the first assessment, the result was 6 over 6 on the Scale for Contraversive Pushing (SCP) and 16 over 17 on the Burke lateropulsion scale (BLS). With regard to the initial Barthel score, the score was 0. At the end of treatment, a significant improvement was obtained with results of 0.25 on the Scale for Contraversive Pushing and 0 on the Burke Lateropulsion Scale. The final result from the Barthel index was 5.

Conclusions

The treatment applied to the patient improved the pushing behavior until it was completely reduced according to the score of these scales. Despite the decrease in the alterations particular to this behavior, improvement in functional capacity was not obtained, maintaining very low values on the Barthel index. This can be explained why the patient as well as presenting with a strong push had quite severe hemiplegia that showed almost no improvement during the treatment period. This case may open the door to other types of treatments in pusher patients but more research is required on the subject.

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Functional connectivity in resting state as a phonemic fluency ability measure

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Introduction

Recently, it has been demonstrated that spontaneously activity in the brain "at rest" are not by chance [1]. This "resting state" (RS) activity is well structured and has similar amplitude to those that appear during task performance [2]. The use of functional connectivity (FC) measures in RS may serve to predict individual differences in performance of cognitive tasks [3]. Using a phonemic fluency task, this work will investigate this possibility by studying FC in phonemic fluency brain areas at rest.

Methods

Resting state fMRI (rs-fMRI) data from ninety-three right-handed participants (mean age=20.65±2.697; 37 male) and their performance in the Spanish version of COWAT [4] were used. A total of eight seed-regions (Table 1), which were extracted from Wagner et al (2014) meta-analysis of neuroimaging studies using the phonemic fluency task [5], were defined as 6-mm radius spheres and used in the FC analyses. Rs-fMRI datasets were processed by means of DPARSF Advanced (http://rfmri.org/DPARSF) [6]. Then, FC ROI-wise analyses (pair correlations between ROIs) were conducted. SPSS was used for Pearson correlation analyses between the COWAT phonemic scores and seed-regions FC z-values. Significant correlations were used to define a multiple regression analysis (stepwise method), whose aim was to identify the seed-regions that would influence in phonemic fluency ability.

Region	Hemisphere	Brodman's Area	MNI coordinates
Inferior Frontal Gyrus (LIFG)	Left	9	-50 12 24
Insula (LIns)	Left	13	-44 18 6
Supplementary Motor Area (LSMA)	Left	32	-2 14 48
Supplementary Motor Area (RSMA)	Right	24	4 32 34
Insula (RIns)	Right	13	44 16 -12
Thalamus	Left		0 -22 14
Caudate Head	Right		22 24 -4
Putamen	Left		-16 6 6

Table 1. Regions with significant activation during phonemic verbal fluency [5]

Results

Pearson correlation analyses yielded significant positive correlations between phonemic fluency scores and brain connectivity of pairs LIns-RSMA and Thalamus- Putamen. On the hand, significant negative correlations were found with pairs LIFG-RIns, LIns-Caudate and LSMA-RIns. The regression model (corrected R^2= .135; $F_{3,89}$ = 5.78, p < 0.001) was reached in five steps, contained four of the five predictors with one of them removed from the model (pair left Thalamus-left Putamen).

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Conclusions

In the present study we used FC measures on rs-fMRI data to predict phonemic fluency performance. The results indicate that FC between relevant brain areas during the phonemic task could be a good predictor of phonemic fluency abilities. In fact, FC between areas in the left hemisphere was positively correlated with performance, whereas FC between target areas located in different hemispheres correlated negatively with performance. These results may contribute to measure phonemic fluency in clinical populations and can avoid the problems that involve working with patients.

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Kinect-based occupational therapy virtual environment for functional neurorehabilitation of the upper limb

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Introduction

The use of virtual reality technologies has attracted great interest in the area of functional neurorehabilitation [1]. These technologies have a strong ludic component that can increase motivation. Furthermore, Kinect-based motion tracking enables us to individualize the exercises and to generate knowledge [2]. The aim of this research is to perform a proof of concept test of a virtual environment for upper limb rehabilitation. To this end, we have designed two rehabilitation virtual scenarios based on occupational therapy activities. Activities are monitored by a control system based on Microsoft® Kinect sensor [3], for performing bilateral hand coordination and finger dissociation rehabilitation exercises. Both virtual scenarios have been validated by expert therapists at the Institut Guttmann of Nerurrehabilitación and a preliminary evaluation has been performed with four traumatic brain injury patients.

Methods

The virtual environment prototype was developed according to a specific neurorehabilitation process modelling methodology [4]. First, we performed an analysis of the occupational therapy activities that are currently used in the Institut Guttmann Hospital. Next, we chose two activities for their adaptation and implementation on a virtual environment. The first activity is a bilateral hand coordination task in which the patient has to move a wooden disc along a plastic rod. The second is a finger dissociation activity that stimulates the movements of the hand. In this activity the patient has to press specific keys on a piano or keyboard to play a certain pattern. Once these activities were selected, two virtual environments were designed to allow patients to perform rehabilitation tasks. Microsoft® Kinect was chosen as the primary hardware device to monitor and control. Moreover, to develop the control system we used 3GearSystem software [5]. Virtual environments were developed using the Unity development platform [6].

Results

The virtual environment for upper limb rehabilitation has been developed. This system allows patients to execute the two designed activities. The first activity has been designed as a car driving game, whilst the second activity represents virtual musical instruments that can be played with arm and finger movements (Figure 1).

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Figure 1. Virtual content graphical interfaces.

The virtual environment has been installed and validated in the Institut Guttmann - Hospital. Four patients participated in the validation process (Table 1). After performing the activities, patients performed a usability test. The test included a satisfaction questionnaire. The questionnaire was scored from 1 to 5 representing responses from left (worst) to right (best). Test results showed a high level of acceptance for both activities. However, several limitations were identified in the current prototype. The most important limitation is the lack of haptic feedback to help patients perform the finger dissociation activity. Another limitation that must be considered is the lack of a support system to guide patients when they needed help.

Patient	Age	Diagnosis	Motor involvement	Period since injury (days)	Acceptance level (1-5)
1	27	TBI	Predominantly right tetraparesis	89	4,5
2	29	TBI	Predominantly left tetraparesis	239	4
3	54	TBI	Predominantly left tetraparesis	119	5
4	44	TBI	Predominantly right tetraparesis	204	5

Table 1. Patients' characteristics and acceptance test results.

Conclusions

This research presents a low cost virtual environment prototype for the rehabilitation of the upper limb based on computerized occupational therapy tasks. A proof of concept test has been done and evaluated showing how these tools are widely accepted by patients to perform treatment activities. Furthermore, the usability test allows the identification of main limitations of the current prototype to improve. A new version of the system is under development to be tested in a larger scale of patients.

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Automatic computer-based brain tumor volume detection

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Introduction

The initial diagnosis of intracranial neoplasms is based on determining their location or apparent extension by imaging techniques although the final diagnosis is anatomopathological. Once the etiology is established and the treatment is planned, evolutionary controls by image analysis are performed. Nowadays, lesion evaluation is carried out measuring tumor maximum diameters in the axial slice where the tumor is larger. In general, from 1 to 3 diameters are used for describing tumor size and later comparison. This method is overly simplistic because it assumes that the lesion is a sphere and its borders are well defined. However, this method is widely used for its simplicity in spite of leading to an underestimation of the total lesion size. Tumor dimensions depend directly on tumor morphology and on the observer. Therefore, it is a method of low reproducibility.

Accurate measurement of brain tumor volume is a critical indicator of disease and treatment effectiveness since it allows to assess neoplastic growth delay and size reduction. In particular, when robust and reproducible methods for tumor size assessment are used, the obtained information is the most important predictor of patient evolution [1].

The goal of this work is to provide clinicians a powerful tool to automatically determine brain tumor volume from anatomical images to use this variable in post-treatment evolutionary controls. The software will be used for the prospective and retrospective tumor analysis. The aim of this tool is to simplify the diary work of radiologists and provide an objective and quantitative tumor volume comparison which is observer-independent.

Methods

Tumor segmentation is performed through brain magnetic resonance image (MRI) processing. It is assumed that there is only one tumor by anatomical image and it will be located in one of the brain hemispheres. The block diagram of the software is shown in Figure 1.

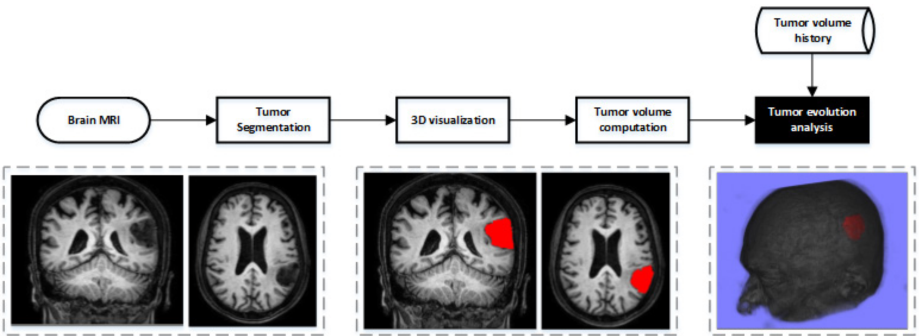

Figure 1. Block diagram of the proposed software.

First, the skull is stripped by means of a tool included in SPM software package [2]. Then, the brain symmetry axis is determined [3] and both hemispheres are independently analyzed to find out tumor location. In particular, the histograms of each hemisphere are fitted by Gaussian distributions and they are compared to appreciate the difference between hemispheres. The

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zone of each hemisphere with the highest probability of being tumor is detected. This selection is based on intensity level differences. Therefore, two possible areas, one by each hemisphere, are identified by thresholding and, afterwards, they must be processed to determine which one belongs to the tumor. The center of both areas are used as markers in marker-controlled watershed transformation [4] to segment the borders of the suspicious areas in an accurate way. Finally, final tumor detection is based on several geometrical properties. The largest and most eccentric and compact area is chosen as tumor.

Results

The method proposed for tumor segmentation is able to identify different type of tumors independently of their grey intensity level (meningiomas, glioblastomas, cavernomas, etc.). In Figure 2 some results of the method are depicted.

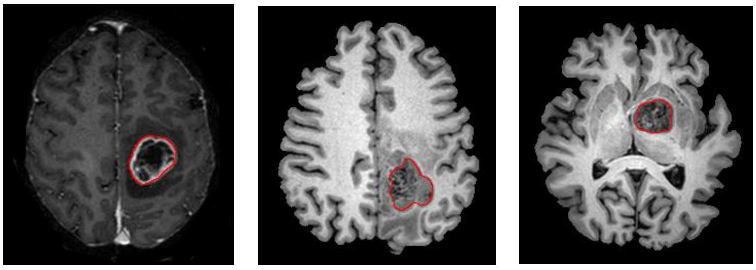

Figure 2. Tumor segmentation results.

Conclusions

In this paper, a software for prospective and retrospective analysis of brain tumors is presented. This tool simplifies radiologist work providing objective and quantitative tumor volume measures which can be used in controls of patient evolution.

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Smart toys for detecting children developmental delays

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Introduction

Toys and playing are crucial for the overall development of a human being. They are key tools that contribute to socialization and self-identity construction along childhood due to their highly motivating nature, ability to motivate learning and generate emotions.

The process to get evidence about a developmental difficulty or to diagnose a delay in the different developmental areas of a child is often a hard task. The reasons of this complexity are the variability in the ranges of standard development and the improvable accuracy of the assessment tools.

The goal of this research is to enrich the accuracy of traditional evaluation methods by embedding sensors into daily life toys that provide professionals with added value supplementary information enhanced by decision-support systems. Thus, it will be possible to detect potential disorders in a standard child development that might go unnoticed by traditional ways.

Methods

TecnoNEET2010 principles [1], the paradigm of Internet of Things [2] and the "Design for all" rules [3] set up the baseline of the smart toys sensorization work that make use of inclusive and interactive technologies which are fully guided by educational purposes.

The approach is to take advantage of the natural and spontaneous interaction of the children with the so created smart toys, everyday objects and other people during their normal activity at common scenarios such as the home and school. A secure knowledge-based information system will provide teachers, parents and other professionals with acquired information that will foster requested reasoning processes for early detection of potential anomalies and early stimulation activities. Figure 1 shows the general architecture of the scenario: sensorized toys gather raw data from children's interaction and submit it to a collector device that shares it with a Data Analysis platform. This data is managed by an Artificial Intelligence based platform to transform it into suitable information that may help children´s development specialists, teachers and parents to enhance their knowledge about the physical, sensitive or cognitive abilities of each child. The user interface provides parents and professionals with comprehensive and customised information about the developmental status of the monitored child [4].

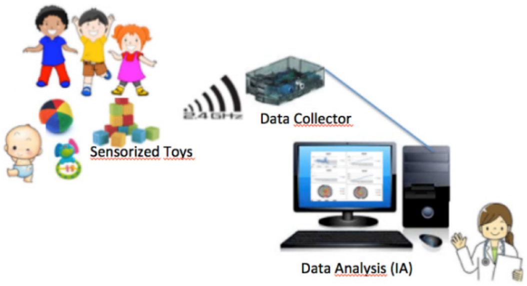

Figure 1. Architecture of the scenario.

The interaction process is detailed in Figure 2. A child plays with a ball equipped with movement sensors. This toy collects raw data like "x acceleration" to be processed under expected developmental abilities. The system reports a Normal Ball movement and the Aid Decision-Making helps the specialist to diagnose a Normal behaviour.

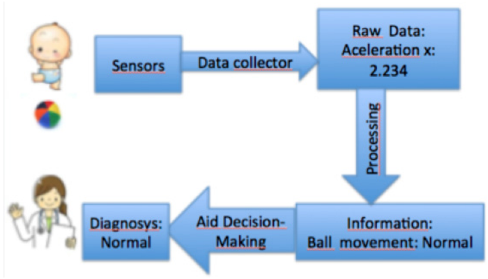

Figure 2. Children-Smart Toy-Specialist detailed Interaction Process.

Results

A systematic analysis of the interaction milestones and key stages of the child's development [5, 6] led to decide the use of rattles, balls and cube towers to monitor the skills and behaviour of children aged between 0 and 5 years.

Therefore, three types of sensoring technologies are embedded into the smart toys: i) accelerometer and gyroscope to measure movement pattern and handling time while the child plays with the toy, ii) force sensors to measure grip strength when the child grabs a rattle or a cube, and iii) a flexometer to measure grip strength when the child holds a ball.

The results of reviewing early years' movement skills and assessment tools [7, 8] were grouped into three age groups to work with: a) Children aged between 0 and 1 year who play with rattles to monitor pressure, contact surface, movement pattern and handling time; b) Children aged between 1 and 3 years that play with cube towers to measure the previous parameters plus grip strength and time spent to stack a cube on the tower; c) Children aged between 1 and 5 years who interact with balls to register grip strength when the child graps a ball, the ball's movement pattern and previous parameters.

Conclusions

Smart toys help to acquire, register and provide dynamic information about children's development in cognitive and sensorimotor areas. This facility eases the monitoring and registration of a child's evolution to correlate data acquired from his or her interaction with the one obtained by traditional methodologies. It is expected an improvement in the accuracy and quickness to detect risks or delays at the development of children in real time. Consequently, early response to detected problems can be performed by triggering stimulation and early attention activities.

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Use of virtual reality game as part of exercise program for chronic kidney disease patients undergoing haemodialysis

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Introduction

Haemodialysis treatment is the most common treatment for end stage renal disease patients. Haemodialysis substitutes the renal function but is associated with several alterations that lead to decrease in functional capacity and health related quality of life (HRQoL). It has been shown that exercise may contribute to improve health status of this cohort. Virtual Reality has the potential to assist current rehabilitation techniques in addressing the impairment, disabilities and handicaps associated with different pathologies as brain injuries, but there is no knowledge about the impact of this technique in haemodialysis units. The purpose of this pilot study was to evaluate the suitability of a virtual reality system (ACT) for chronic kidney diseases (CKD) patients undergoing haemodialysis.

Methods

The system has been designed to be cost-effective and with an easy integration in the clinical environment. ACT uses MsKinect© for tracking purposes, running under a conventional PC. ACT presents a game-scheme for patients to improve their motivation.

32 patients with CKD undergoing haemodialysis from the dialysis unit in the Dr Peset Hospital (Valencia, Spain). Patients were included if they were at least 3 months undergoing haemodialysis treatment. Amputate patients also were included in the study.

After an introduction to the game and their aim, each patient performed one session of the virtual reality game (ACT). In ACT, the patient had to take the coins that appeared in the monitor with one leg and they could change the leg when they felt tired (see figure 1). They had to play 2 minutes without pause. After the game they had to complete a questionnaire to evaluate suitability with the virtual reality game: the Suitability Evaluation Questionnaire (SEQ)

The primary outcome measures are provided by the questionnaire. The total score of the SEQ questionnaire ranges from 13 (poor suitability) to 65 (excellent suitability). To calculate this total score, we consider all of the questions to be positive, except for Q7, Q8, Q9, Q10, Q12, and Q13, which are considered to be negative questions.

Statistical analyses were performed with Excel Office programme.

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Figure 1. Patient playing and try to take the coins that appears in the monitor.

Results

The 14th item of SEQ was not included in the calculation, because this is an open-response question. Taking both positive and negative questions into account, the mean total score for the questionnaire was (mean ± SD) 60.78 ± 3.35, and the individual total score ranged from 52 to 65points. Since the SEQ score ranges from 13 (poor suitability) to 65 (excellent suitability), these results show that the patients perceive the system to be a system with good suitability. The score for the question 1 (Did you have fun with the game?) ranged from 3 to 5 (mean ± SD = 4,63± 0,61); and the question 11 (Do you think this game can be useful to increase your muscles?) ranged from 1 to 5 having a mean of 4,59 ± 1,01 of SD). In addition, an informal interview was done after completing the questionnaire. The informal interview is a subjective source of data, but it is always very interesting to know the opinions of patients. The patients considered that ACT is can be a good tool to have fun during the time they are in hemodialysis and most of them, as we can see in the results, think ACT can be useful for them to increase their muscles.

Conclusions

The SEQ results show that ACT meets the requirements of usability, acceptance, and security of use. This ACT could be used as an aid rehabilitation to increase the activity levels in patients with CKD during their haemodialysis session. A follow-up study examining its effectiveness in improving the inferior limbs in CKD patients undergoing haemodialysis is recommended

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Virtual reality and language processing: the impact of virtual actions on verbs comprehension and learning

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Introduction

In the last decade many data have been reported that support the hypothesis of an embodied nature of language [1]. According to this framework, linguistic processing takes place in our brain as a result of the activation of different cortical regions, including sensory-motor cortices [2]. In this perspective, Virtual Reality (VR) can be considered an 'embodied technology' for its effects on body perceptions [3]: it is possible the use of VR for inducing controlled changes to the experience of the body, such as to give the user the opportunity to see themselves moving in the virtual world while being comfortably seated in a chair. The present studies have been conducted to investigate the effect of a virtual action on second language learning and comprehension. The goal was to elucidate if and under which conditions the virtual action can promote language processing.

Methods

Two experiments were conducted on healthy adults. In experiment 1, participants had to explore a virtual park while learning 15 new verbs (action verbs, describing movements performed with either the hand or the foot and abstract verbs) in Czech language. This learning condition was compared to a baseline condition, in which movements (neither virtual nor real) were allowed. The goal was to investigate whether the virtual action (performed with the feet) would promote or interfere with the learning of verbs describing actions performed with the same or a different effector. The number of verbs correctly remembered in a cued recall task was computed, along with reaction times and number of errors during a recognition task. Participants completed an ITC-Sopi questionnaire [4] as a measure of the sense of presence in the virtual environment. In experiment 2 we investigated language comprehension, comparing two conditions that differed about the motor task: one in which the participants performed a virtual action with their feet (running in a virtual world, Run condition), and one in which they only watched at others performing that action (looking at a video of runners, Video condition). In both conditions, participants had to perform a concomitant go-no go semantic comprehension task, in which they were asked to press a button (with the right hand) when the verb of the presented sentence was concrete and to refrain from providing response when the verb was abstract. Action verbs described actions performed with hand, foot or mouth. We recorded EMG latencies as a measure of reaction times of the linguistic task. The goal was to investigate whether the virtual action (performed with the feet) would promote or interfere with the comprehension of verbs describing actions performed with the same or a different effector.

Results

In experiment 1 we found that the number of errors for foot action-verbs recognition was influenced specifically by one of the ITC-Sopi's subscale, Ecological Validity (the tendency to recognise the environment as real-like): when this index was higher, the errors decreased; more, Ecological Validity was predicted to yield less errors in the Run condition than in the Baseline condition (Figure 1). No effects were found on the number of verbs correctly recalled, nor in RTs.

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In experiment 2, results underlined that those who virtually run in the environment were faster in understanding foot-action verbs compared to those belonging to the Video condition (Figure 2).

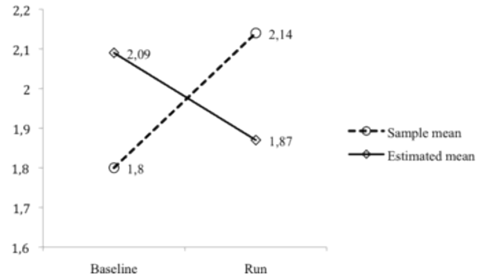

Figure 1. Experiment 1. The impact of the Ecological Validity for the number of recognition errors related to foot action-verbs

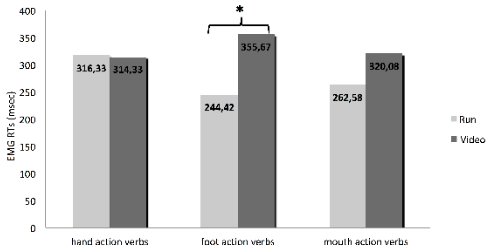

Figure 2. Experiment 2. Performances of the two groups for each type of action verb. * indicates a difference statistically significant

Conclusions

Results of experiment 1 highlighted that the virtual action had no effect *per se* on the number of item learned; on the other hand, it could help recognizing the correct translation of verbs performed with the same effector when the virtual environment was perceived as real-like. Results of the experiment 2 indicated that a virtual action promoted the comprehension of verbs describing actions performed with the same effector. On the whole, therefore, we found that VR can be targeted in order to impact language processing, taking advantage from the link between language and motor system. This observation has important rebounds in the field of rehabilitation: if the association of a virtual action to verbal material facilitates comprehension and learning in non-pathological samples, it should be investigated if this effect is replicable in people with language deficit. Moreover, often patients with different types of aphasia have motor deficits as well, and VR could give them the opportunity to take advantage of the action-language coupling protocols even without moving at all.

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Ultrasonic echo intensity to assess changes of skeletal muscle quality in chronic stroke subjects

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Introduction

In the hemiplegic leg of subjects with stroke, muscular atrophy [1], fatty infiltration [1], and muscle fiber phenotype shift [2] are structural abnormalities that cause disability. These alterations could be managed by exercise-based physiotherapy to reverse consequences of paresis.

Ultrasonography imaging, implemented with computer-aided gray scale analysis, has been used to assess quality of skeletal muscle [3]. Increased intramuscular fibrous and fat tissue in skeletal muscles correspond to enhanced echo intensity (EI) on US images [3-5]. Therefore, this parameter can be useful.

This paper aimed at studying the use of EI to assess changes of the vastus intermedius (VI) muscle quality in patients with chronic stroke.

Methods

A double blind controlled trial was carried out. Fourteen subjects (45.85% men, mean age 58.2± 9.78) with chronic deficits resulting from stroke (onset > 6m) were recruited. They were randomly allocated to an interval training programme (intervention group, n=7) or to a conventional therapy focused on upper limb retraining (control group, n=7).

To assess VI muscle quality, cross-sectional echo images of the anterior compartment of the hemiplegic thigh were performed. A B-mode ultrasonography imaging device (SonoSite Titan, Sonosite Inc., Bothell, WA, USA) and a multi-frequency linear probe (5–10 MHz) were used.

Each participant was lying supine, with the hemiplegic knee near to the natural resting position (10–20° of flexion). The transducer was held perpendicular to the longitudinal axis of the quadriceps muscle, at 1/3 of the thigh length from the anterior superior iliac spine and the knee joint space [6]. Measurements of the VI muscle were taken in relaxation and in contraction.

In the ultrasound image, a region of interest (ROI) was selected in the VI muscle without any bone-surrounding fascia (figure 1). The value of EI was determined by a gray-scale analysis using Matlab R214 (MathWorks Inc.,Natic, Massachusetts (USA), licensed from the University of Valencia). EI was defined as the mean pixel intensity of the ROI and was expressed in values between 0 (black) and 255 (white). The mean EI of this region was used for analysis.

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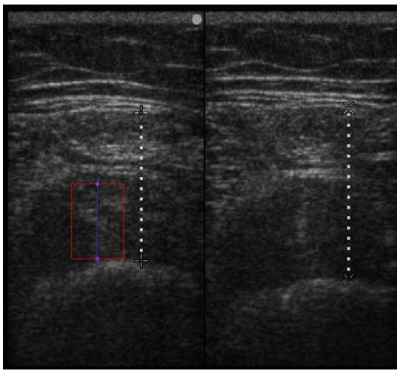

Figure 1. Example of ROI selection.

Descriptive statistics (mean, standard deviation) were calculated for EI values by time, group and muscle action. To assess changes of VI muscle quality, a three-way ANOVA [group (intervention vs control) x action (relaxed vs contraction) x time (pre vs post)] was performed, with Bonferroni post-hoc analysis. Significance level was set at .05.

Results

No significant interaction between variables was observed. There was a time effect in the VI muscle quality (table 1), though not significant (p=0.94). In the control group, average EI values in relaxation increased, while they remained similar in the intervention group. This may be the consequence of a lower replacement of contractile tissue by fat and fiber due to the aerobic treatment.

	Intervention group (n=7)	Control group (n=7)
Pre-intervention		
Relaxation	38.6 (3.67)	39.93 (7.17)
Contraction	32.32 (6.87)	30.53 (9.05)
Post-intervention		
Relaxation	38.32 (10.61)	42.76 (9.99)
Contraction	30.29 (6.78)	30.66 (10.63)

Table 1. Results of EI by group, time and muscle action.

Conclusions

An innovative method to investigate muscle tissue quality in patients with chronic stroke was proposed. It can reflect changes in muscular structure, showing suitability of EI as an index of muscle quality in subjects with chronic stroke. Nevertheless, since sample size was small, results are not applicable to the whole population and future research on a larger sample is needed.

Acknowledgements: This study was carried out through the collaboration agreement between Nueva Opcion- Brain Damage Association of Valencia and the Physiotherapy Department of the University of Valencia.

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Functional principal component analysis as a novel methodology to clarify the effect of two physiotherapy programs for walking recovery after stroke

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Introduction

Regain the ability to walk is one of the main objectives in rehabilitation after stroke [1]. Physiotherapy in stroke patients using a mix of components from different approaches is more beneficial than no treatment, but future research should clarify which specific techniques are more suitable for walking recovery after stroke [2]. However, determining if a physiotherapy program is more appropriate than others is a hard task as researchers find several limitations, such as small number of subjects or a huge variability in functional recovery process between subjects after stroke [3].

Functional Principal Component (FPC) analysis is a potentially useful tool to cope with these limitations [3]. Moreover, FPCs capture the geometry of functional data, instead of paying attention to a set of points of the function so they allow gathering all the temporal information contained in the function.

We propose the use of FPCs in force curves of gait as an analytical tool for the assessment of different physiotherapy programs in gait recovery after stroke.

Methods

A randomized double-blind controlled trial was performed. Subjects with residual hemiparesis after a single stroke episode were included. Basal techniques from different approaches were the same in all patients' treatment, but plantar stimulation sensitivity, movement dissociation and extra balance techniques were added to the target group to find out their effectiveness. Kinetic pattern during the stance phase of walking was assessed by the NedSVE/IBVv4 system once a month when subjects were able to walk unaided to six months after stroke onset. For each step, three-dimensional ground reaction force (GRF) normalized by the weight of the subject was obtained. The statistical analysis was performed using FPC analysis.

Results

Twenty subjects (73.20±9.0 years) completed the protocol (target group n=10). On average, walking velocity (control group: 0.63±0.30 m/s, target group: 0.89 ± 0.40 m/s) was similar in both groups at the beginning of the study ($t(10)=-1.330$, $p=0.213$). Kinetic data from 65 steps showed significant differences between groups in some scores (fitting coefficients of FPCs). In the vertical component (Fz) during the stance phase of the paretic leg (Figure 1) three scores presented differences between groups: score 2 ($F(1)=4.089$, $p=0,048$), score 3 ($F(1)=5.499$; $p=0.023$) and score 4 ($F(1)=6.599$; $p=0.013$). Smaller values on the score 4 in Fz, as happened in the target group (0.01±0.45, versus control group= 0.18±0.05), were related to a more normalized advancement strategy of the contralateral lower limb that is in the swing phase [4]. Moreover, the score 1 of the mediolateral component in the stance phase of the non-paretic leg (Figure 2) also showed statistical differences between groups (U=275.000, p=0,001), indicating better walking stability as the magnitude of mediolateral forces is minor.

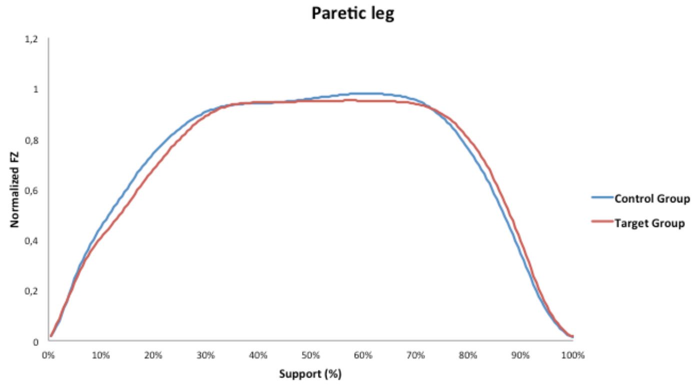

Figure 1. Reconstructed curves from marginal means of the scores with statistically significant differences in the vertical GRF component in the paretic leg.

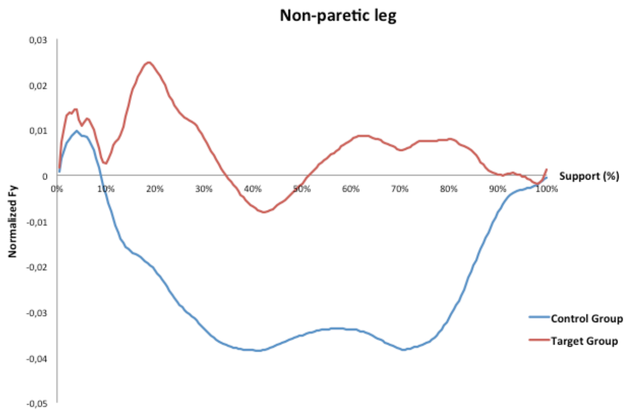

Figure 2. Reconstructed curves from marginal means of the scores with statistically significant differences in the mediolateral GRF component in the non-paretic leg.

Conclusions

Specific techniques added to the target group are relevant to get a more normal gait pattern. FPC analysis provides a useful approach for the purpose of analyzing walking recovery trends when there is a huge variability as in the case of stroke patients.

Acknowledgements: The authors wish to thank patients and Stroke Rehabilitation Team of Hospital Universitari i Politècnic La Fe (Valencia, Spain). This research has been partially funded by the European Commission under FP7 program in the project BETTER (BNCI-driven Robotic Physical Therapies in Stroke Rehabilitation of Gait Disorders) Ref: FP7-ICT-2009-247935. This abstract is based on the dissertation submitted in fulfillment of the "Doctoral Programme in Ageing Processes: Social and Health Care Strategies", held at the Faculty of Physiotherapy (University of Valencia).

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Two different physiotherapy programs in order to improve participation in chronic stroke

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Introduction

Owing to the high prevalence of disability in stroke older adults, participation can be severely affected. According to the International Classification of Functioning, Disability and Health 2001, participation involves functioning in life. In Rehabilitation Medicine, there has been a growing concern about it as a way to assess success of treatment. However, appraisal of participation in stroke research is scarce [1].

In all stages after a stroke, Physiotherapy interventions in favor of intensive high repetitive task-oriented and task-specific training have obtained benefits on trained actions and activities [2]. But, the effect of this type of treatment on the impact the disease has on patient´s participation is underinvestigated.

The aim of this study was to determine which kind of physiotherapy task-oriented training program could better improve participation in chronic stroke subjects: an upper limb strength training program (ULST) or a combined cardiovascular/task-oriented interval training (IT) program.

Methods

A randomized single-blind controlled trial was carried out. Fourteen subjects with chronic hemiplegia resulting from stroke (onset >6m) were recruited. All participants were fully informed about the experimental procedures and the aim of the study. Written informed consent was signed by each subject prior to participate. Approval from the ethics committee of the University of Valencia was obtained for the study.

Subjects were randomly allocated to an ULST program with elastic bands (n=7) or to a cardiovascular/task-oriented IT program (n=7), focused on walking capacity. In the ULST group, a nine 5-minute station circuit session was designed (figure 1A). Patients work 2+2 minutes in each exercise, with a 30-second rest between the 2-minute periods and between stations. The IT program consisted of a set of 8 cardiovascular exercises at moderate intensity (figure 1B), interrupted by 1-minute active breaks of task-oriented exercises. Duration of both programmes was 3 months (3 sessions/week).

Participation was assessed by the Stroke Impact Scale (SIS-16) and the Frenchay Activities Index (FAI), before and after the intervention. Differences by group were evaluated using the Student´s t-test or Mann-Whitney U test, as appropriate. Differences by time were assessed by paired t-test or Wilcoxon signed-rank test, as appropriate. The level of statistical significance was set a priori at 5%.

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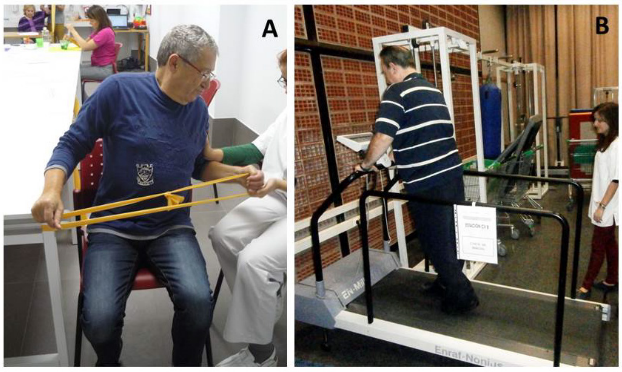

Figure 1. Example of a circuit station in the upper limb strength training program (A) and in the combined cardiovascular/task-oriented interval training program (B)

Results

All the participants (mean age 58.5±9.8 years) completed the study. The average number of attended session was 27.28±4.8 (26.14±7.44 in the cardiovascular/task-oriented IT group, 28.42±4.11 in the USLT group, p=0.491). The feasibility of each intervention, assessed by number of adverse events during sessions, was excellent (n=0). At the beginning, there were no statistically differences between groups either in SIS-16 or in FAI. All subjects improve their participation according to both scales, though no significant within-subject effect was found. However, participants in the combined cardiovascular/task-oriented IT program showed a higher increase on the FAI and SIS-16 mean scores than the ULST group as shown on table 1. Dimensions that resulted in higher changes were outdoors activities and social activities.

	Before intervention		After intervention		P-value	
	IT	ULST	IT	ULST	IT	ULST
SIS-16						
Total	58.57±17.42	63.57±10.58	62.28±14.44	63.86±11.77	0.255	0.928
FAI						
Total	30.00±8.78	35.43±12.76	33.00±6.76	36.00±11.37	0.184	0.569
Indoors activity subscale	8.71±4.72	10.57±7.23	8.29±3.82	11.6±0.53	0.461	0.450
Outdoors activity subscale	12.86±4.45	14.86±5.87	14.71±3.59	16.57±4.43	0.095	0.078
Social activities subscale	5.57±1.40	6.43±2.30	6.43±1.81	5.14±2.41	0.339	0.098

Table 1. Results by time. SIS: Stroke Impact Scale; FAI: Frenchay Activities Index

Conclusions

A combined cardiovascular/task-oriented interval training program may be more effective in improving participation in subjects with chronic stroke than upper limb strength training. However, due to the small sample size, these results must be interpreted with caution and future studies are guaranteed.

Acknowledgements: This study was carried out through the collaboration agreement between Nueva Opcion- Brain Damage Association of Valencia and the Physiotherapy Department of the University of Valencia.

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Suitability of a virtual mindfulness system designed for patients of a palliative care center: a preliminary study

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Introduction

Nowadays, due to the improvements in technology it has been possible to introduce virtual reality (VR) systems in many areas. This has been possible by the reduction of hardware costs and to the higher deployment of ICT in society [1]. In the health field, VR systems are used in different areas, from rehabilitation to psychology. In psychology, there are also an increase in the use of therapies based on meditation and mindfulness [2]. Several studies have shown its effectiveness in neural rehabilitation, attentional capacity, productivity, creativity and relaxation [3].

The goal of this research is improving the physical and emotional consciousness in patients residing in a palliative and convalescence care unit. To achieve this objective we have developed a system that complement the therapeutic work relaxing patients.

In this document we describe the developed system and we present the results of the usability evaluation in healthy subjects.

Methods

To achieve the objectives we have developed an Android application to induce relaxation. Through it, patients feel immersed in a familiar environment, and they can guide their walk for the environment.

The population for this study consists of 13 healthy subjects (5 women and 8 men), aged 17–58 years (mean 26.5±12.4).

With regards to the instrumentation, the hardware used in this study was a "BQ Edison 2 Quad Core" Tablet with Android 4.2.2 OS installed. The developed application allows the realization of fully configurable virtual tours with real videos and images and visual and audio stimuli controlled by the therapist. The patient has the freedom to choose different paths and the possibility of interacting with the system to change the speed of tours and the point of view. We have developed a short test scenario where we can see all the possibilities of the system.

The first step in the evaluation is the explanation of the system with the help of the user manual (2 min). After, the user test the application in the short test scenario (3-6 minutes, see Figure 1). Finally, the user completed the SEQ questionnaire [4].

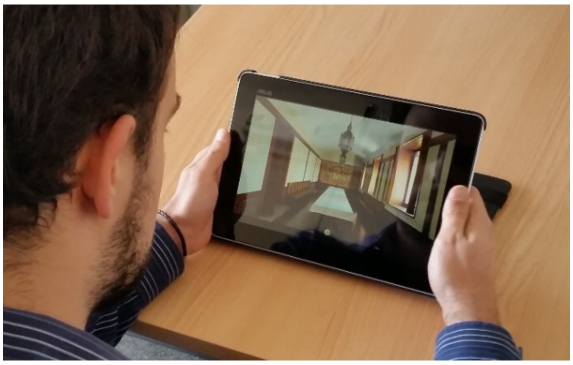

Figure 1. User testing the application.

Results

The evaluation of the application has been done over a group of 13 persons. The SEQ final score of the system is 59±2.70 using the method described in [4].

Question	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
Mean	3,68	4,43	4,67	3,01	4,64	4,43	1,04	1,00	1,00	1,26	4,33	1,00	1,15
Std. deviation	0,60	0,66	0,60	1.12	0,48	0,66	0,28	0,00	0,00	0,66	0,51	0,00	0,63

Table 1. Results of SEQ evaluation.

Conclusions

Based on the obtained SEQ results we can assert that the developed application overcomes the objectives of usability, acceptance, and security of use. It is particularly interesting the high results obtained in the questions 2, 5, and 6, that are related with ecological validity of the VR system. Also, the very low punctuation of the questions 7, 8, 9, and 10 (related with the problems arising from the use of the system) is noteworthy. The overall score achieved by the SEQ is 60, an excellent result considering that SEQ score ranges from 13 (poor suitability) to 65 (excellent suitability).

Currently we are introducing the system in the palliative and convalescent unit of the Hospital San José for a new evaluation with patients. With patients we are evaluating relaxation and stress management as well as usability, accessibility, and security of use with patients.

In future studies we intend to adapt the application to new platforms, improving the accessibility. Furthermore, we aim to introduce new functionalities for automatic evaluation of the condition of the patient, such as eye-tracking or measuring heart rate during the tours. On the other hand the application of the techniques used in this study in other areas is proposed.

Acknowledgements: The authors wish to thank the clinical specialists from San José Hospital (Teruel, Spain) for their collaboration.

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New therapies for upper limb after stroke

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Introduction

Stroke is a major cause of death and disability throughout the world, consuming significant resources. It is therefore highly important that stroke services are effective and efficient. Problems affecting the upper limb following stroke are often persistent and disabling, with only 20% to 56% of patients regaining useful upper limb function after three months. Therefore, determining the most effective and efficient ways to deliver stroke rehabilitation services is a matter of priority, being nowadays even more important because of developing New Therapies.

Methods

We searched the Cochrane Database of Systematic Reviews. We included systematic reviews that compared the New-rehabilitation-therapy with usual-rehabilitation or no- rehabilitation. The primary outcome of interest was the effect of the programme on Activities of Daily Living (ADL), as it is known that the most important goal for patients is to improve their ability to participate in and independently achieve independence with ADL. We also included upper limb motor impairment as a secondary outcome, because it has been shown to be the most influential factor in determining well-being, one year after stroke.

Results

There was insufficient evidence to determine if home therapy programmes were more or less effective than usual care (visits to hospital or local health centre or hospital inpatient care), no intervention or a placebo intervention.

We found evidence that the use of virtual reality and interactive video gaming may be beneficial in improving upper limb function and ADL function when used as an adjunct to usual care (to increase overall therapy time) or when compared with the same dose of conventional therapy. There was insufficient evidence to reach conclusions about the effect of virtual reality and interactive video gaming on grip strength. It is unclear at present, which characteristics of virtual reality are most important and it is unknown whether effects are sustained in the longer term.

Telerehabilitation has the potential to facilitate access to services and reduce costs associated with providing rehabilitation programmes. Most studies were conducted with people in the chronic phase following stroke. There were no statistically significant results for independence in activities of daily living neither for upper limb function. Evidence was insufficient to draw conclusions on the effects of the intervention on mobility, health-related quality of life or participant satisfaction with the intervention. No studies evaluated the cost-effectiveness or the occurrence of adverse effects of telerehabilitation.

About brain stimulation by transcranial direct current stimulation (tDCS), currently, evidence of very low to low quality suggests the effectiveness of tDCS (anodal-tDCS/catodal-tDCS/dual-tDCS) versus control (Sham-tDCS or any other approach or no intervention) for improving generic

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ADL and function after stroke. However, evidence of high quality indicates that no effect regarding dropouts and adverse events can be seen between tDCS and control groups.

Conclusions

We have analysed four New Therapies and only one, Virtual reality and interactive video gaming, has scientific evidence nowadays of being beneficial in improving upper limb function and ADL function. Home therapy programmes, telerehabilitation and transcranial direct current stimulation are therapies that may offer new advantages to our patients upper limb functionality, however there is insufficient evidence at present to reach conclusions about.

Therefore, more research in the form of adequately powered high-quality randomised controlled trials is required.

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Automatic modified Jebsen test of hand function using Microsoft Kinect

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Introduction

An important aspect on the rehabilitation of motor function in stroke patients is the regular evaluation of the patients' functional level. To ensure objectivity, validity, and repeatability, validated motor function tests should be used. Even though many motor function tests are very simple, they must be performed by a therapist. If these tests could be performed automatically, the objectivity would be increased and the test could possibly be used at remote sites without direct supervision. In this paper, the design and test of an automatic method for implementing the validated, modified version of the Jebsen Test of Hand Function (MJT) is described [1,2].

Methods

A total of 10 healthy subjects (20-30 years old) participated in the study. Signed consent was obtained from all subjects and the Declaration of Helsinki was respected. The study was approved by the local ethical committee (N-20130053).

Three subtests of the MJT [2] was administered to each subject. In the subtests, the subjects had to turn around five paper cards (S1), pick up and move five kidney beans, placed on a board against a ridge, to a cylinder using a teaspoon (S2), and stack four checkers on top of a board (S3). The outcome measure was the time taken to complete each subtest. Time was measured using a stop-watch and automatically by using a Microsoft Kinect camera. Each subtest was performed twice, once with the dominant hand (D) and once with the non-dominant hand (N).

The Kinect camera was positioned 120 cm above the table for capturing movements in the task area (the table) during the tests (Figure 1).

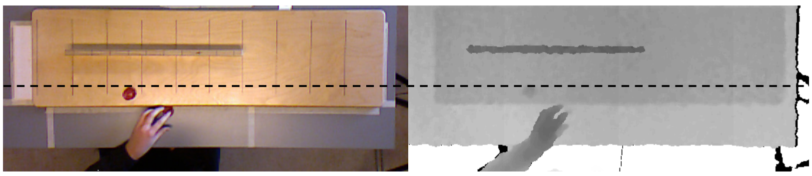

Figure 1. RGB and depth image output from the Kinect camera during S2

The hand was detected by identifying the largest group of connected pixels located more than 50 mm above the table surface in the depth image. The timing of each subtest was started when the hand crossed the horizontal centerline of the image (dashed line on Figure 1).

The cards used in S1 had a green marker on one side (initially facing down), which became visible once the card had been turned. The green markers were identified using the RGB image. When five green markers had been detected, the timing was stopped.

In S2, the cylinder was detected using the RGB image. Any movements (identified by comparing previous frames to current frames) within the region of the cylinder were identified to detect beans being dropped into the cylinder. The timing of the subtest was determined when five beans had been detected.

The checkers used in S3, were identified using the depth image. In each frame, pixels with a distance more than 10 mm from the board surface were identified. Timing was stopped once

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the difference between the distance to the board and the identified pixels exceeded 3.5 times the height of one checker.

Results

The average difference in the outcome of the two methods for each subtest is shown on Figure 2.

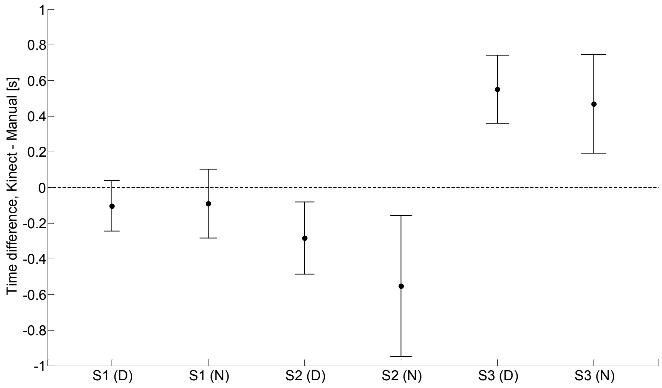

Figure 2. Time differences (mean±95% CI) between the two methods for each subtest.

All time differences between the methods were within ±1s. Time differences between the two methods for S1 are not significantly different from 0, while this is not the case for S2 and S3.

Conclusions

In this paper, an automatic method for implementing three subtests of the MJT was described. The automatic method was evaluated by tests in healthy subjects. In future work, the automatic method will be evaluated in stroke patients.

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Promoting "brain health". Which interventions may be useful for delaying cognitive aging?

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Introduction

In a demographic context characterized by a rapid growth in the elderly population, we need to develop interventions aimed to promote a successful cognitive aging and to identify opportunities for prevention. The goal is to counteract, or at least delay, age-related cognitive decline and neurodegenerative disorders such as Alzheimer's disease [1,2].

In recent years, the concept of "brain health" has emerged in the scientific literature as a goal what we can achieve implementing different strategies [3]. However, no systematic reviews have been published regarding the main initiatives and resources developed in last years in order to promote a better knowledge of the concept of "brain health" among healthy adult and aging population. Recently, there have been several initiatives focused in brain health maintenance emphasizing modifiable risk factors [4]. Our aim to integrate the main resources we can find in the scientific literature, mass media and in the web regarding the promotion of "brain health" resources.

Methods

We have performed a systematic search in Pubmed including studies about "brain health". In addition, a "Brain Health Resource's Guide" (in Spanish) has been elaborated including news, blogs, webs and other sources of interest for disseminating this fundamental concept for public health. This is an example (Figure 1) of the material included in this guide.

Results

The search performed with the keywords "brain health" in Pubmed retrieved only 3 papers. For that reason, we broadened our search including more keywords (prevention cognitive aging brain) and selecting those papers that specifically include the promotion of brain health or of strategies related to it. Some initiatives were identified both in English language (FINGER study, Women's Health Initiative...) and in Spanish ("Vivir con Vitalidad", "Cuida tu Cerebro"...) although none of them has an integrative perspective including all modifiable risk factors for cognitive aging.

The "Brain Health Resource's Guide" was performed searching in Google, Scholar Google and other databases and taking into account materials dealing with "brain health" which offer a scientific foundation. The Guide includes 7 books, 8 webs, 15 blogs, 27 news, 7 videos, 2 playlist, 6 brain training platforms, 6 links to social networks and 4 mobile apps although this list is continuously being updated. We also designed an intervention program aimed to promote the knowledge of the "brain health" concept among healthy adults.

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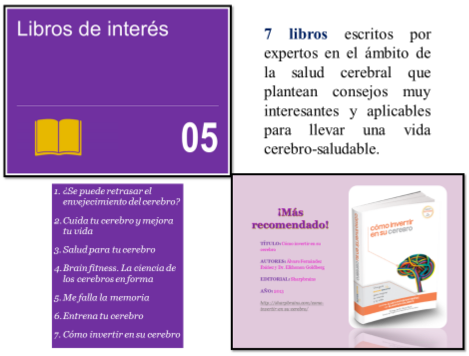

Figure 1. An example of the Resource's Guide for "Brain Health" in Spanish

Future studies are needed in order to complete the Guide we have developed (in Spanish) and to broaden it including also interesting materials published in English.

Conclusions

1. In general, materials aimed to promote brain health emphasize one of the factors which can aid to a more successful aging (i.e, cognitive training, physical activity...) but there are no integrative reviews about the topic.
2. Brain health as a goal may be one of the interventions which may help to maintain cognitive functioning throughout life.
3. The aim of achieving a better brain health would need an integrative approach from neuroscience, technology and innovation [3].
4. Public health efforts are necessary in order to obtain a more wide promotion of the "brain heath" concept and their implementation among different populations.

We need to move from a model centered in disease to a model focused in brain health. It's necessary to translate this message to the population.

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Memory assessment using a spatial recognition task

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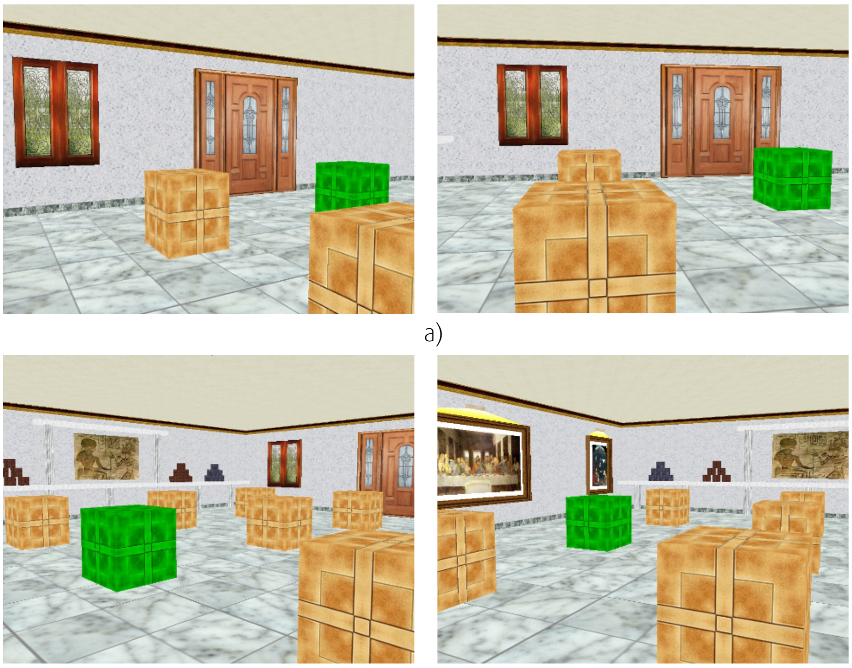
Introduction

Virtual reality-based tasks provide a valid method to measure spatial memory. Its efficacy has been proved in several studios. However, technological demands could create a bias during the assessment. Thus, old people could show problems to master some devices used for navigating in virtual reality contexts.

On the other hand, experience with virtual reality contexts can be modulated by the active vs passive role of the subject during the learning phase. Those tasks demanding a passive participant role could solve some of these issues. The aim of this study was to create a spatial memory task combining video presentation and a spatial recognition test.

Methods

A total of 96 healthy students from the University of Almeria participated in this study. They watched four videos from a first person viewpoint. Immediately after each video, subjects had to decide whether or not any of the 10 pictures shown in a recognition task corresponded to any of the spatial positions showed in the video. Images could be taken from similar viewpoints (Figure 1.a) or from very different perspectives (Figure 1.b). In addition, the video could show one or three spatial positions to be remembered.



a)

b)

Figure 1. Images taken a) from similar viewpoints; and b) from different viewpoints.

Results

Males outperformed females in the spatial recognition task when images were taken from different points of view. However, there were not significant differences when images showed

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a similar viewpoint. In addition, groups did not differ when the number of positions to be remembered was reduced to one.

Conclusions

Subjects can acquire the task in few trials and males are better than females when judging spatial perspectives in a high demanding task. This probably shows the use of different strategies.

Acknowledgements: This work was supported by a predoctoral grant (FPU) to Laura Tascón and by the Ministry of Economy and Competitiveness (Spain) [PSI2011-26985].

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Opportunities and challenges when implementing a rehabilitation robot (ROBERT) at a nursing home

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Introduction

The demographic development towards a bigger elderly population and a smaller working-age population increases the pressure on the health care system [1], which already is at a first place with regards to industries that are most affected by work-related deterioration [2]. Staff with work-related diseases represents a great economic cost, and work-related diseases are strongly associated with loss of quality of life [3]. Bedridden patients require a great effort by health professionals and a relevant rehabilitation intervention, including repetitive physical exercises [4], which makes rehabilitation robots potentially interesting. These robots might spare the health care professionals for heavy and repetitive movements. Rehabilitation robots have been used in gait training and rehabilitation of the upper extremities with encouraging results [5,6] [7]. Nevertheless, the success of such robotic devices also depends on whether they can be successfully implemented in the health care system. Therefore, the objective of this study was to investigate the opportunities and challenges when implementing a rehabilitation robot (ROBERT) for bedridden patients at a Danish nursing home.

Methods

The robot used in this study was an industrial robot modified to contribute to the mobilization of bedridden patients. It consisted of 6 active joints and an end device that allowed moving the extremities in various pre-programmed manners.

To investigate what the participants considered as opportunities and challenges when using ROBERT in the rehabilitation of bedridden patients, a qualitative research design was chosen based on a semi structured interview and participant observation [8].
First, a Living Lab event was established in a Danish nursing home (Figure 1) to observe the participants' initial reactions to the robot, and partly give them an understanding of what ROBERT is. ROBERT was placed in a room where participants were invited to come and see, test, and ask question about the robot. After the Living Lab arrangement, the participants answered a semi structured interview about opportunities and challenges when using ROBERT.

Five health care professionals, including an administrative leader, and three residents at the nursing home.

Kvale and Brinkmann’s meaning condensation was used as inspiration for the coding and interpretation [8].

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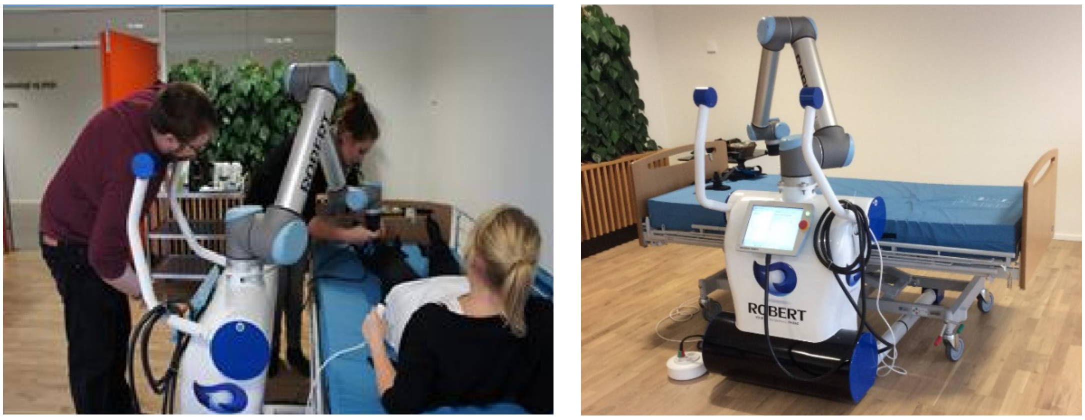

Figure 1. ROBERT at the Living Lab event

Results

Four themes emerged from the analysis of the observations and interviews (Table 1).

Theme	Results	Who contributed to this theme
Robotics in the health care system	The participants expressed a concern about ROBERT replacing the humans in the health care system.	3 Health care professionals 3 Residents
Opportunities and challenges in the use of ROBERT	The participants saw it as an opportunity that ROBERT could provide more training and repetitions, because it could relief more time from the health care professionals. The participants saw opportunities in ROBERT such as rehabilitation of different parts of the body e.g. arms, legs and trunk. Also They expressed that ROBERT seemed large and robust, which was seen as a challenge and a necessity - a challenge when transporting and navigating the robot, and a necessity to feel safe when letting the robot lift the body weight of the residents.	5 Health care professionals 2 Residents
Involvement when implementing ROBERT	It was essential for the participants to be involved when a new technology should be tested and implemented at the nursing home.	4 Health care professionals 0 Residents
Motivation for rehabilitation	The participants expressed a need for a technology, which could relieve the workload of the health care professionals. . However, the participants saw economic challenges when implementing ROBERT.	5 Health care professionals 1 Residents

Table 1. Results from the observations and interviews

Conclusions

This study concluded that there were potentials in the use of a rehabilitation robot like ROBERT for the mobilization of different body parts of bedridden patients. Also several different groups of patients and with different intentions. The participants thought that ROBERT could contribute to more training and repetitions in the exercise and ROBERT could relief some of the work done by the health care professionals. The challenges referred to the design of ROBERT and the economic aspect of implementing the robot at a nursing home.

Acknowledgements: We would like to thank Bent Sørensen at Fremtidens Plejehjem for arranging the contact with the participants in this study.

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VirtuaCyL: development and validation of a ubiquitous system based on Android for educational support of children with autism in TEACCH methodology

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Introduction

The rate and prevalence of children with autism spectrum disorder (ASD) is increasing according to recent studies [1]. The educational process for these children requires special characteristics compared with that follow children without ASD. Since Eric Schopler founded the Treatment and Education of Autistic related Communication Handicapped Children (TEACCH) [2], this has been used in the education of many children around the world. However, the TEACCH program has some limitations caused by space and material resources needed. VirtuaCyL will be a portable system based on Android, which aims to recreate virtually work environment characteristic of TEACCH program using pattern recognition and virtual exercises without relying on a specific classroom of communication and language. VirtuaCyL also will control the educational process, and will evaluate the progress of the children. The "low cost" of VirtuaCyL will facilitate its integration in homes and ordinary schools.

Methods

VirtuaCyL will have two essential parts: software and hardware.

With regards to the software, VirtuaCyL will offer several cognitive rehabilitation exercises, each associated with a specific virtual environment (VE) (Figure 1). The objective will be to teach cognitive skills to the children with ASD by these VE. The VE can be configured to suit the cognitive level of children and allow teachers to customize exercises with individualized materials. In addition, VirtuaCyL will allow only a certain type of exercise if the predetermined conditions have been met, and that can be detected by pattern recognition.

Figure 1. Sample screen

With regards to the hardware, VirtuaCyL will use portable devices based on Android, which allow the children to visualize VEs in a sufficiently immersive way, and to interact in an intuitive way. Nowadays there are several "low cost" devices which offer these features. Considering this, VirtuaCyL proposesa10" tablets default device to watch the VEs and to interact with them by means of its touch-screen. The tablet camera will allow performing pattern recognition.

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Results

VirtuaCyL is a work-in-progress. We still have no clinical outcomes, but we have developed the clinical protocol to obtain results in several months. Nevertheless, we believe in their high chance of acceptance among teachers and families of children with ASD. We think the potential of VE, pattern recognition and natural interfaces, can provide a significant advance in the solution of the skill training and other problems mentioned previously. Moreover, VirtuaCyL has been designed considering the specifications of the Fundació MIRA'M and Departamento Psicobiología (Universitat València) professionals, who are dedicated to the care and educational training of children with ASD. Fundació MIRA'M professionals also designed the clinical protocol, are going to evaluate the clinical population, and will integrate the system in their special education school.

Conclusions

We have realized the importance of integration of the tools used in the educational process of children with ASD, because all the tools developed so far are isolated from a particular methodology. And this results in a difficulty for teachers. We have also verified the need for children with ASD may have adequate working conditions at the lowest possible cost, material resources and space assets and economic resources at the same time. VirtuaCyLis an attempt to analyze how these new technologies can help to this solution.

Acknowledgements: The authors wish to thank the psychologists of the Centro Privado de Enseñanza Parroquial Don José Lluch (Valencia-Spain) for their collaboration, and also the teachers and professionals of Fundació MIRA'M and Departamento Psicobiología (Universitat València) that provides us of knowledge, specifications, clinical protocol and ASD population to develop our system.

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Erigo® in the rehabilitation of disorders of consciousness and Balance Master® in mild brain injury patients: our experiences

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Introduction

In the rehabilitation of Disorders of Consciousness (DOC) reduction of immobilization is a major clinical goal, since prolonged bed rest may lead to the following negative effects:

- Significant decrease in ROM in several somatic joints
- Increasing in spasticity with difficulties in treatment
- Vital parameters (HR, d-s) may get worse
- May affect consciousness recovery as responsiveness to external stimuli is likely to be delayed

Nonetheless identifying appropriate and effective methods to reduce losses and even to restore exercise capacity is challenging during prolonged bed rest of minimally responsive patients. Balance dysfunction represents another devastating result of mild brain injury (BI). In the management of patients recovering from severe and mild Brain Injury assessing and training balanced movement may be the most significant part of rehabilitation. The clinical goal is to minimize disability and improve functional performance in everyday life tasks.

Methods

Our clinical experience with Erigo®, an innovative tilt table combined with a computer controlled stepping mechanism, and Balance Master®, a device which consists of two fixed force plates that measure the vertical forces exerted by the patient's feet, will be illustrated through video supports and data collections on a sample of minimally responsive patients and brain injured patients admissed at Neurorehabilitation and Coma Unit.

Results

In an early phase of rehab in Vegetative State/Minimally Conscious State patients treatment with Erigo® may help to maintain passive ROM of lower limbs and to improve vital parameters, may enhance muscle relaxation so can be used in patients with spasticity as an alternative to passive mobilization and is safe and without side effects. Furthermore, a possible Erigo® based therapy influence on level of consciousness may exists even if further studies are needed.

The Balance Master® provides objective assessment and eventually it can be used for training of sensory and voluntary motor control of balance with a visual biofeedback.

Conclusions

Future prospectives for the implementation of new technologies for systematic evaluation and rehabilitation treatment of patients with DOC and severe and mild BI will be discussed.

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