Poster F1: Anxiety and Depression in Patients with Malformations of Cortical Development and Incomplete Hippocampal Inversion

Cognitive/Language Rehabilitation

Bhoopathy R M, Arthy B, Vignesh S S, Srinivasan A V
Madras Medical College, chennai, India

Background of the study:

Anxiety and depression often lowers the quality of life. The frequency of occurrence of seizure, presence of structural abnormalities of the brain and antiepileptic medication has significant adverse effect in anxiety and depression of persons with intractable epilepsy. Hence we wanted to study the anxiety and depression levels in intractable seizures with Malformations of Cortical Development (MCD) and Incomplete Hippocampal Inversion (IHI) or malrotation of hippocampus.

Main Objective:

1) To find out the prevalence of anxiety and depression in patients with MCD and IHI.

2) To compare the anxiety and depression levels in patients with intractable epilepsy with structural abnormalities (MCD & IHI) and without structural abnormalities.

Methods:

Three groups of patients with intractable epilepsy were considered for the present study from 410 patients attended our epilepsy clinic at Institute of Neurology, Madras Medical College. Group I - 41 patients with no abnormalities of brain, b) group II - 17 patients with MCD, c) group III – 30 patients with IHI. Groups were classified based on the 1.5 T MRI imaging with PSGR volumetric studies. Patients were then administered Multiphasic personality questionnaire who IQ scores above low average intelligence in weschlers adult intelligence scale.

Results:

From the multiphasic personality questionnaire administered anxiety and depression score above cut off point were observed in 9 &12 patients in group I, 1 & 7 patients in group II and 10 & 11 patients in group III. It was also observed that all epilepsy patients had high prevalence of depression than anxiety. The mean score for anxiety and depression were 8.36 & 6.17 in group I, 6.82 & 6.41 in group II and 9.63 and 6.63 in group III patients. Independent samples kruskal –Wallis Test showed significant difference in anxiety scores across the group ($p<0.05$). No significant difference was observed for depression between the groups.

Conclusion:

Anxiety and depression are highly prevalent in intractable seizure with normal MRI findings as well as in patients with MCD and IHI. Subjects in MCD group had low average intelligence compared to other two group thus they showed reduced prevalence of anxiety.

Conflict of interest: nil

Poster F2: Increased Interhemispheric Coherence During Transcallosal Inhibition Assessment in Chronic Stroke: A Preliminary TMS-EEG Investigation
Stroke

Michael Borich[1], Lewis Wheaton[2], Sonia Brodie[3], Bimal Lakhani[3], Lara Boyd[3]
[1]Emory University, Atlanta, Georgia, USA, [2]Georgia Institute of Technology, Atlanta, Georgia, USA, [3]University of British Columbia, Vancouver, British Columbia, Canada

Introduction: Reorganization and remodeling of motor network connections contributes to recovery of arm function after stroke. Changes in effective network connectivity in humans after stroke can be studied using concurrent transcranial magnetic stimulation (TMS)-electroencephalography (EEG). The primary objective of this study was to use imaginary coherence (IC) analysis of TMS-evoked EEG responses to directly characterize interhemispheric interactions between the primary motor cortices (M1s) in individuals with stroke.

Methods: Ten participants with chronic ischemic stroke in the right (n=5) or left (n=5) hemisphere and four age/gender matched healthy controls were tested. Standard TMS procedures were conducted bilaterally. Transcallosal inhibition (TCI) was evaluated by delivering single suprathreshold (150% resting motor threshold) TMS pulses over M1 while performing an ipsilateral grip force contraction (50% maximum). Suprathreshold TMS pulses were also delivered at rest. 64-channel EEG recordings were collected concurrently during TMS assessments.

All data pre-processing steps were performed in EEGLAB. Epochs were extracted for each participant and concatenated within each group for IC analysis. Post-TMS (0-300ms) IC values between electrodes overlying M1 (C3, C4) bilaterally were calculated within the beta frequency band (15-30Hz) as the primary dependent measure of interhemispheric IC. Secondary analyses subdivided the stroke group based on lesion hemisphere. Level of physical impairment was evaluated using the upper extremity portion of the Fugl-Meyer (FM) Assessment.

Results: Individuals with chronic stroke showed greater TMS-evoked interhemispheric IC compared to controls ($p=.017$) during TCI assessment. No differences were seen during the rest condition. Greater interhemispheric beta IC during TCI was observed in participants with lesions in the right hemisphere regardless of stimulation site. Participants with lesions in the left hemisphere exhibited greater arm impairment (median FM score: 16) compared to individuals with right hemispheric lesions (median FM score: 57).

Discussion: Preliminary findings suggest increased interhemispheric interactions between M1s during an active motor state are present in chronic stroke and may contribute to persisting disability.

Poster F3: Effect of Resveratrol on Relapsing-Remitting Multiple Sclerosis
MS

Matthew Davis[2], Pradeep Sahota[1, 2] Mahesh Thakkar [1, 2]
[1] Harry S. Truman Memorial Veterans Hospital, [2]University of Missouri School of Medicine, Columbia, MO, USA

The use of meta-analysis in basic biomedical research has increased in recent years due to differences in genetically modified mice producing inconsistent results. Resveratrol (RSV) is a naturally occurring polyphenol that has been shown to affect numerous biological pathways, leading to many health benefits. Several of these benefits include anti-inflammatory and neuroprotective properties that have implicated RSV as a possible therapy for relapsing remitting multiple sclerosis (RRMS). Recent research with RSV has been focused on a mouse model of MS called experimental autoimmune encephalomyelitis (EAE), but results have not been consistent. In the present study, we performed a meta-analysis of the data related to the effect of RSV on RRMS. The meta-analysis revealed a slight delay in the onset and progression of EAE in mice treated with resveratrol, as well as a decrease in peak symptom severity determined by a clinical scale score. Overall, mice treated with EAE showed a slower disease progression, including the number of days to reach peak clinical score and the number of days it took for the mice to reach minimum relapse score. This study suggests that, despite many positive effects, RSV has not shown statistically significant results as treatment for regulating the clinical presentation of EAE. Meta-analysis will be run on other aspects of the effect of RSV on RRMS before presentation, including its neuroprotective effect, quantified by level of retinal ganglion cell (RGC) axon damage and number of spinal cord lesions with preliminary analysis indicating a significant positive effect following treatment.

Poster F4: The Effect of Antispasmodic Medications on Recovery During Inpatient Rehabilitation After Acute Traumatic Spinal Cord Injury
SCI

Eric R. Theriault[1,4], Vincent Huang[2], Gale Whiteneck[3], Marcel P. Dijkers[2], Noam Y. Harel[2,4]
[1]New York Institute of Technology, Old Westbury, NY, USA, [2]Icahn School of Medicine at Mount Sinai, New York, NY, USA, [3]Craig Hospital, Englewood, CO, USA, [4]James J. Peters VA Medical Center, Bronx, NY, USA

Objective: Recovery from spinal cord injury (SCI) and other neurological disorders occurs partly through activity-dependent neural plasticity. By inhibiting neural activity, we hypothesize that antispasmodic medications may reduce plasticity and adversely affect outcomes after SCI. We queried the SCIRehab database to determine whether use of antispasmodic medications during inpatient rehabilitation affected neurological and functional outcomes during the first year after acute traumatic SCI.

Design: Retrospective analysis of prospectively obtained data.

Participants/methods: The SCIRehab study collected data on patients with traumatic SCI admitted to acute inpatient rehabilitation at six centers between 2007 and 2009. We analyzed the patient-level database for International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) grade and level; Functional Independence Measure (FIM); and types and doses of antispasmodic medications administered. Patients were considered to have received antispasmodic medications if they received at least 5 doses of muscle relaxants, benzodiazepines, or botulinum toxin during inpatient rehabilitation. Data was analyzed at inpatient admission, discharge, and one-year follow-up.

Results: 1,376 patients, 1111 male and 265 female, with an average age of 37.6 (range 12-88), were included in the analysis. 60.3%, 35.0%, and 4.7% were injured at the cervical, thoracic, and lumbosacral levels, respectively. 49.5% were ISNCSCI grade A, 16.5% were grade B, 18.5% were grade C, and 15.6% were grade D. Motor FIM score at admission averaged 23.5 (95% CI 22.9-24.0).

During acute inpatient rehabilitation, 686 patients (49.9%) received at least 5 doses of antispasmodic medications. Patients with cervical injuries were more likely to receive antispasmodic medications (58.1%) than those with thoracic (37.6%) or lumbosacral (35.4%) injuries.

After controlling for baseline injury severity and level at inpatient admission, motor FIM scores at inpatient discharge were significantly higher in patients not given antispasmodic medications (53.8, 95% CI 52.7-54.9) than in those who received antispasmodic medications (48.5, 95% CI 47.4-49.6) ($p<0.0005$). Likewise, motor FIM scores at one-year follow-up were significantly higher in patients not given antispasmodic medications: 63.9 (95% CI 62.3-65.5) versus 59.9 (95% CI 58.2-61.5) ($p=0.001$). These effects persisted after performing Rasch transformation - baseline-adjusted, Rasch-transformed FIM motor scores were higher in those not given antispasmodic medication: at discharge, 48.4 (95% CI 47.7-49.1) versus 45.4 (95% CI 44.7-46.2) ($p<0.0005$); at one year, 57.5 (95% CI 56.2-58.9) versus 55.3 (95% CI 53.9-56.6) ($p=0.022$). Antispasmodic medication did not significantly affect discharge ISNCSCI grade.

Conclusion: Antispasmodic medications may adversely affect functional recovery during inpatient rehabilitation from acute traumatic SCI. We speculate these consequences could be mediated by a combination of reduction in neural plasticity and other drug side effects. Randomized prospective studies are needed to further evaluate the effect of antispasmodic medication on neural and functional recovery.

Support: NIDRR grants H133A060103, H133N060027, and VA RR&D grant B0881-W.

Poster F5: Paired Stimulation to Increase Cortical Transmission to Hand Muscles
SCI

Lok Yung[1], Shivani Kastuar[2], Jason B. Carmel[3], Ann M. Spungen[1,2], William A. Bauman[1,2], Noam Y. Harel[1,2]
[1]James J. Peters VA Medical Center, Bronx, NY, USA, [2]Icahn School of Medicine at Mount Sinai, New York, NY, USA, [3]Burke Medical Research Institute, White Plains, NY, USA

Objective: After neurological injury, repetitively activating spared circuits strengthens synaptic connections. We aim to use a novel combination of non-invasive magnetic and electrical stimulation to strengthen connections between motor cortex and hand muscles in subjects with cervical SCI or ALS.

Design: Prospective crossover device intervention pilot study (clinicaltrials.gov NCT02469675).

Participants/methods: Two groups of participants are being studied: individuals with chronic incomplete cervical SCI (n=12), and those with definite or probable ALS (n=6). After baseline testing, subjects undergo 7 combinations of unpaired or paired magnetic and electrical stimulation: transcranial magnetic stimulation (TMS) over the hand motor cortex, monophasic peripheral nerve stimulation over the median nerve at the wrist, or biphasic cervical root stimulation transcutaneously across the neck. Each session comprises unpaired or paired stimuli every 10 seconds for 20 minutes (120 stimuli). Paired stimulation is timed for TMS pulse arrival at cervical motor neurons either 1.5 ms before or 10 ms after electrical pulse arrival. Functional and physiological testing is conducted at baseline and 0, 15, 30, and 90 minutes post each intervention. Key outcome measures include grip strength dynamometry, timed performance on a hand dexterity test, amplitude of abductor pollicis brevis motor evoked potential, flexor carpi radialis H-reflex responses, and duration of the 'cortical silent period' after TMS stimulation during APB contraction.

Results: Preliminary results from the first subjects to undergo paired stimulation will be presented. We hypothesize that one session of paired stimulation augments corticospinal transmission for at least 30 minutes when electrical pulses are timed to arrive at cervical motor neurons 1.5 ms after TMS pulses. Cervical electrical stimulation is anticipated to demonstrate equal or superior efficacy to median nerve stimulation. We speculate that paired stimulation facilitates cortical transmission to hand muscles through spike timing-dependent plasticity.

Conclusion: The cervical stimulation technique offers several advantages over other approaches to neural stimulation: it is non-invasive, it activates multiple levels and both sides simultaneously, and it has the ability to target novel interaction sites for convergent peripheral and corticospinal input onto cervical motor neurons. These features offer the potential to strengthen cortical control over multiple arm and hand muscles using one stimulation paradigm.

Support: VA RR&D grants B0881-W and B9212-C.

Poster F6: Threshold Position Resetting Suppressing both Stretch Reflexes and Background Muscle Activity in Response to Prolong Muscle Lengthening

Motor Rehabilitation

Nicolas Turpin[1,3], Rim Rahal[1,3], Sandeep Subramanian[2,3], Mindy Levin[2,3], Anatol Feldman[1,3]

[1]Department of Neuroscience, Université de Montréal, Montréal, Canada, [2]School of Physical and Occupational Therapy, McGill University, Montréal, Canada, [3]Center for Interdisciplinary Research in Rehabilitation of Greater Montreal, Montréal, Canada

Since the work of Sherrington (1906), it has been recognized that, together with other proprioceptive reflexes, the stretch reflex (SR), i.e. position- and velocity-dependent resistance to muscle lengthening, plays a fundamental role in the control and stability of posture and movement. The spatial threshold of the SR, i.e. the muscle length or respective joint angle at which the SR begins to act is broadly regulated by spinal and supra-spinal systems in a task-specific way. We tested the hypothesis that the SR threshold can be reset to suppress both SR reactions and background muscle activity in response to high amplitude lengthening, thus preventing overstretching active sarcomeres. The forearm and hand of subjects (n=12) were placed on a horizontal manipulandum. Elbow flexor or extensor muscles were pre-activated by compensating an external load (1-3 Nm) applied to the manipulandum by a torque motor. The muscles were stretched by rotating the manipulandum by 60 ° at different velocities (8-120°/s) randomly selected for each trial. EMG signals (biceps brachii, brachioradialis, triceps brachii lateralis and medialis), displacement and velocity were recorded. In training trials and subsequent experimental trials, subjects were instructed to abstain from intentionally modifying their responses to perturbations. Trials in which subjects changed EMG levels prior to stretch onset were excluded. SR responses to muscle stretch (lengthening), if present, were minimal and occurred at latencies of 25-35 ms and after about 70 ms the EMG activity was suppressed for about 80 ms. After that the stretched muscles were reactivated during the ongoing muscle lengthening. Results are consistent with the notion of resetting of spatial thresholds for muscle activation, rather than with suppression (gating) of the SR in time. In general, threshold resetting is used not only to prevent muscle overstretching but also in the control of intentional movement. By doing so, the nervous system converts posture-stabilizing to movement-producing mechanisms, thus solving the classical posture-movement problem. Spatial threshold resetting can also be used to prevent falls in subjects standing on a platform that is suddenly tilted. The possible relationship between the notion of SR threshold resetting and the clasp-knife phenomenon in some neurological conditions is discussed.

Poster F7: Track-Weighted Functional Connectivity in the Sensory Discrimination Network Correlates with Haptic Performance: A Preliminary Study in Stroke
Neural Repair Mechanisms

Alexandra Borstad, Petra Schmalbrock, Deborah Nichols-Larsen
The Ohio State University, Columbus, OH, USA

Purpose/Hypothesis: Complex haptic tasks such as sensory discrimination require efficient processing between multiple brain areas. Novel methods, which combine the structural and functional imaging, such as track-weighted functional connectivity (TW-FC) proposed by Calamante and colleagues, may be sensitive to, and inform our understanding of the neural correlates of haptic performance. The purpose of this preliminary study was to 1) measure the test re-test reliability of TW-FC 2) to compare TW-FC in the sensory discrimination network in stroke and control participants. We hypothesized that 1) TW-FC would be reliable and sensitive to stroke-control group differences and 2) TW-FC would correlate with sensory discrimination performance.

Subjects: Ten community-dwelling individuals with hemiparesis as a result of chronic stroke, with mild to moderate deficits in upper extremity function and 10 age, gender and handedness neurotypical controls provided written consent to participate in this IRB approved study. The mean (SD) age was 67(10) years for post-stroke and 65(10) for controls. Chronicity of poststroke participants was 27(26) months.

Materials/Methods: Behavioral outcomes were monofilaments, the Hand Active Sensation Test (HASTe) and the 6-item Wolf. A 3 T MR scanner (Philips, Achieva, The Netherlands) with a body transmit and 8-channel receiver coil was used for structural and functional MRI scans. Blood oxygen level dependent (BOLD) T2* weighted functional MRIs in the transverse plane were obtained using Gradient Echo-Echo Planar Imaging with parallel imaging and a sensitivity encoding reduction factor of 2. (TR/TE=3000/35ms, flip angle=90°, FOV=230x230x140mm, matrix=80x80 interpolated to 128x128). Functional MRI data was analyzed using FSL. Diffusion tensor images were acquired in the axial plane with parameters: TR/TE=8000/68 ms, FOV=230x230x140mm, Matrix=116x114, Slice thickness/ gap=2.0/0.0mm, two b-values 0 and 1000 s/mm2, diffusion weighting gradient directions=60, SENSE reduction factor of 2, scan time of 9 minutes. TW-FC maps were generated using tools in MRtrix3.

Results: Between group differences were not statistically significant for either somatosensory measure. HASTe scores and TW-FC values were normally distributed. Paired t-tests revealed no between group differences for the 3 TW-FC ROI's examined: white matter, sensory discrimination network or the whole brain. TW-FC of the white matter was significantly related to age ($r=0.62$, $p=0.003$), lesion volume ($r=0.65.p=0.044$), chronicity ($r=0.81,p=0.004$), and right HASTe scores ($r=0.65$, $p=0.002$) but was not related to touch perception, 6-item Wolf, or brain volume. TW-FC was 1.9% different across ROI's described by Willats, 2014.

Discussion: This preliminary study suggests the TW-FC method, which fuses functional connectivity and structural brain information into a single quantifiable image, is sensitive to neural differences related to haptic performance. TW-FC may be superior to other connectivity methods for longitudinal analysis as the test-retest differences were low.

Poster F8: Does Delayed Peroneal Activation in Response to a Sudden Underfoot Perturbation during Gait Predict Injurious Falls in the Elderly with Diabetic Peripheral Neuropathy?
Peripheral Nerve/Plexus/Neuromuscular Diseases

Hogene Kim[3], Lara Allet[4], Trina DeMott[2], James. K. Richardson[2], James. A. Ashton-Miller[1]
[1]University of Michigan, Department of Mechanical Engineering, Ann Arbor, MI, USA, [2]University of Michigan Health System, Department of Physical Medicine & Rehabilitation, Ann Arbor, MI, USA, [3]National Rehabilitation Center, Seoul, Republic of Korea, [4]Hôpitaux Universitaires de Genève, Geneva, Switzerland

Background: Elderly with diabetic peripheral neuropathy (DPN) have a higher risk of falling and fall-related injuries, especially while walking on irregular surfaces. A slow nerve conduction velocity, common in patients with diabetes mellitus, may play a role. The delayed muscle feedback reaction time (fRT) in diabetes patients' lower extremities may lead to an ineffective reaction in response to an unexpected event. Therefore, the aim of this study was to investigate whether lower limb fRT during gait in response to a sudden underfoot perturbation predicts fall-related injuries in the elderly with DPN.

Methods: 41 elderly with and without DPN (20 female, mean 69.1 yrs) participated in this trial. All participants had a gait evaluation. They were equipped with a pair of custom sandals and were asked to walk 60 times at a comfortable speed on a 10 m level walkway. During each gait trial a discrete 16 mm-high medial (MP) or lateral (LP) underfoot perturbation might be suddenly presented once from the sandal sole under either foot and on any step. Overall the underfoot perturbations (total 8 MP and 8 LP with 4 on each side) were presented in 16 of the 60 trials. Simultaneously fRT measurements in frontal lower limb muscles of peroneus longus, medial soleus, and gluteus medius were made using wireless electromyography electrodes (EMG). The fRT in the recovery steps were compared with unperturbed fRT using post-hoc t-test ($p<0.01$). Participants were then followed for fall-related injuries over a year using self-report and diaries.

Results: Among 31 subjects with valid EMG data, 14 elderly (45.1% of total participants, 71.4% of elderly with DPN) reported a fall-related injury and 12 elderly (75% of normal subjects) had no falls during the following year. In response to a MP, peroneal activation in the elderly without a reported fall was significantly earlier for the first and second post-perturbation recovery steps (1st:-36.5(6.5)ms($p=0.008$),2nd:-50.3(38.1)ms($p=0.016$)) compared to unperturbed steps. However the peroneal activation in participants who reported a fall-related injury remain unchanged during the first recovery step but became significantly earlier during the second recovery step (1st:1.0(13.5) ms ($p=0.116$), 2nd:-31.9(4.5) ms ($p=0.001$)).

Discussion: These finding suggest that earlier peroneal fRT during the first post-perturbation recovery steps is associated with injurious falls in the elderly patients with DPN. Earlier peroneal fRT in the elderly who reported a fall-related injury were delayed during the second recovery step. The perturbing sandal may be a useful assessment to understand neuromuscular functioning in these patients. Future studies might examine the correlation between recovery step kinematics and lower limb fRT during gait.

Acknowledgements: This study was supported by grants from the National Institutes of Health (R01 AG026569-01) and the Public Health Service (P30AG024824).

Poster F9: Neural Correlates of Attentional Demands Associated with Dual-Task Walking
Motor Rehabilitation

Samir Sangani[1], Taichi Kurayama[2], Joyce Fung[1,3]
[1]Jewish Rehabilitation Hospital, Feil/Oberfeld/CRIR Research Centre, Laval, Quebec, Canada, [2]Chiba University, Chiba, Japan, [3]McGill University, School of Physical and Occupational Therapy, Montreal, Quebec, Canada

Walking while simultaneously performing another task requires divided attention, e.g. holding a cup without spilling. Stability control during gait alone requires attention, which may be compromised as the cognitive demand increases. The impact of dual-tasking on biomechanical and neural components is yet to be explored. Our primary goal was to investigate gait pattern changes and the neural correlates of complex dual-task walking using functional near-infrared spectroscopy (fNIRS). Healthy young adults (n=11) and a stroke participant walked on a 3m long force-sensing treadmill (CMill, Motek-Forcelink). Cortical activation was acquired with a NIRScout system (NIRx) using a custom-built cap covering the frontal cortex. The protocol included repeated block trials consisting of four alternating blocks of standing (20s) and walking (25s) at a comfortable speed determined prior to the experiment. Five walking trials were performed, each consisting of four randomized conditions including holding a Styrofoam cup that was empty or filled with water, jelly or hot liquid. Participants held the cup in the dominant or non-paretic hand. Primary outcomes included stride length, step width, stride duration, center of pressure displacements and gait variability (% coefficient of variation in stride duration). The cortical hemodynamic response was quantified by concentration changes of oxygenated hemoglobin (oxyHb) in the frontal cortex. Cortical response maps were determined based on the general linear model using SPM (nirsLAB). Walking with a cup filled with hot liquid was associated with a slight decrease in step width and gait variability in all healthy participants but not the stroke individual. The decrease in step width suggests that all subjects adapted to the back-and-forth slosh frequency of the fluid by adjusting their gait so as to suppress the resonant slosh frequency thereby preventing any spillage. In healthy controls, walking while holding jelly was associated with activation of the supplementary motor area (SMA), whereas holding hot liquid resulted in activation of the premotor cortex (PMC) and dorsolateral prefrontal cortex (DLPFC), which are associated with selective attention. Cortical activation in the stroke participant demonstrated increased activation in the contralesional DLPFC and medial SMA while walking and holding either jelly or water. Absence of significant changes in biomechanical gait parameters suggests that during complex dual-task locomotion, the brain can allocate the required cortical resources to account for increased attentional demands without modifying the inherent locomotor pattern.

Poster F10: Intensive Upper Limb Neurorehabilitation with Virtual Reality in Chronic Stroke: A Case Report

Motor Rehabilitation

Odile Chevalley[1], Thomas Schmidlin[2], Daniel Perez-Marcos[3], Gangadhar Garipelli[3], Robert Leeb[2], Cyntia Duc[3], Ron Vollen[3], Philippe Vuadens[4], Tej Tadi[3], Olaf Blanke[1,2], José d.R. Millán[2,5]

[1]Laboratory of Cognitive Neuroscience, Brain-Mind Institute, Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland, [2]Center for Neuroprosthetics, Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland, [3]MindMaze SA, Ecublens, Switzerland, [4]Clinique Romande de Réadaptation, Sion, Switzerland, [5]Chair in Brain-Machine Interface, Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland

Upper limb motor deficits are a frequent consequence of stroke, limiting patients in their daily life activities. The recovery process is slow and long, including several months or even years of rehabilitation, with the risk of diminishing patient motivation and involvement. Intensive therapy has been shown beneficial, improving the speed of recovery and the degree of independence. In this context, virtual reality (VR) based motor rehabilitation systems provide a potential complement to current therapy in order to intensify the therapy dose and to maintain patients motivation. This study was aimed at evaluating the rehabilitation dose and effect of a VR-based system (MindMotionPRO, MindMaze SA) that enables intensive training adapted to impaired upper limb motor skills in a game-like scenario. The interactive exercises engaged patient's shoulder, elbow and wrist movements with various levels of difficulty. The system provides real-time feedback of patient's performance, with an avatar reproducing his movements on the screen while performing different motor tasks (pointing, reaching, grasping).

A 50-year-old right-handed man, who had a left ischemic stroke 26 months earlier, was recruited for this study. He discontinued the conventional physiotherapy (once per week) in January 2015. At the time of recruitment (NIHSS=3), deficits in his right upper limb were notable in coordinating arm movements, with a Fugl-Meyer Assessment Upper Extremity (FMA-UE) score of 47/66 (Reflexes=4/4; Flexor synergy=9/12; Extensor synergy=5/6; Movement combining synergy=4/6; Movement out of synergy=5/6; Wrist=9/10; Hand=7/14; Coordination/Speed-Finger=4/6). One-hour sessions of intensive VR-based therapy were administered twice per week for five consecutive weeks (10 sessions in total) at the Clinique Romande de Réadaptation (Sion, Switzerland), starting on 21 April 2015. On average, the patient performed 804 goal-directed movements per session with his affected limb. Interestingly, the therapy dose continuously increased from 519 (session 1) to 809 (session 10) repetitions per day. In complement to the training, the patient engaged in daily sport activities. Post-treatment assessments showed an increase of 7 points in FMA-UE score (54/66), with improvements in proximal upper limb control and arm coordination (Flexor synergy=10/12; Extensor synergy=6/6; Movement combining synergy=6/6; Hand=9/14; Coordination/Speed-Finger=5/6). Moreover, the patient reported a positive experience with the technology and showed high levels of engagement during the sessions.

Based on this case report, we surmise that the use of the MindMotionPRO in clinical settings increases the feasibility of adjusting the rehabilitation dose upwards to speed up the recovery. The patient received one-hour intensive VR-based therapy twice a week in addition to sport activities, which contributed to an improvement in his motor outcomes. Intensive VR-based therapy brings thus promising perspectives for maximizing the efficacy of motor rehabilitation in stroke patients.

Poster F11: Task-Oriented Arm Training in Standing Improves Both Anticipatory Postural Control and Upper Extremity Functional Outcomes in Stroke Patients
Motor Rehabilitation

Sandy McCombe Waller, Chieh-ling Yang, Wan-wen Liao, Rogers Mark
University of Maryland Baltimore, Baltimore, MD, USA

Objective: Physical disability resulting from stroke is multifaceted, impacting both upper extremity (UE) and postural control, leaving patients at risk for immobility and falls. In current rehabilitation practice, training is often segmented and targets quite narrowly on one area of disability. As a result, carryover of isolated gains in physical abilities to meaningful context-specific functional performance is limited. To function in an upright world, training should prepare individuals to perform tasks in standing. Moving an arm to reach forward in standing involves anticipatory postural adjustments (APAs) of the legs that precede and accompany the goal directed arm movement, and reactive responses that stabilize balance and prevent falling. This integrated motor task requires the interaction of both corticospinal and subcortical systems. In previous work we identified delayed and reduced magnitude of APAs preceding a functional reach in standing using a cued reaching task using the neural probe of acoustic startle. We hypothesized training the arm in standing without explicit cues for postural adjustments would engage subcortical pathways that contribute to APAs while also improving UE function. We report in this presentation the changes in neural response to acoustic startle, effects on anticipatory postural control and UE functional outcomes after 6 weeks of arm training in standing. **Subjects:** Ten participants with stroke. **Methods:** Neural response to acoustic startle was measured by the presence of startle induced movements during movement preparation and planning. Anticipatory postural control and reaching were evaluated with a cued reaching task in standing. APAs were characterized by onset and maximal displacement of the center of pressure (COP), and onset/offset of EMG from tibialis anterior, soleus. Paretic reach onset/offset and duration were measured. UE functional tests included the Fugl-Meyer UE Test (FM), Wolf Motor Function Test (WMFT), Box and Blocks and the University of Maryland Arm Questionnaire for Stroke (UMAQS). Training consisted of 6-weeks task oriented training with the paretic arm, in standing, with no explicit cues for postural weight shift. **Results:** After training subjects demonstrated, an increase in startle induced movement responses, significant improvements in APAs as measured by onset and displacement of the COP. EMG timing improved post training to resemble timing characteristics of controls previously collected. Both the onset and timing of reaching improved significantly. UE functional gains were seen in FM scores and WMFT (time and weight). Gains in UMAQS scores indicated increased daily use of the arm after training. **Discussion/Conclusion:** Results indicate gains in subcortical neural responses, anticipatory postural responses and paretic reaching in stroke as well as functional UE outcomes. **Clinical Relevance:** Arm training in the functional context of standing may better engage subcortical and corticospinal systems which can lead to gains in both postural control and function of the arm after stroke.

Poster F12: Improved Interhemispheric Inhibition After 12-weeks of Cardiovascular Exercise
Motor Rehabilitation

Keith McGregor[1,2], Joe Nocera[1,2], Bruce Crosson[1,2], Andrew Butler[1,3]
[1]Center for Neurocognitive and Visual Rehabilitation, Atlanta VAMC,, Decatur, GA, USA, [2]Emory University, Department of Neurology, Dectur, GA, USA, [3]Georgia State University, Department of Physical Therapy, Atlanta, GA, USA

Increased aerobic activity in older adults improves multiple aspects of upper extremity motor performance (Spirduso, 1975). In particular, we have recently shown that older adults who exercise on a regular basis show improved psychomotor response speed, faster reaction times and more precise distal manual activity (McGregor et al., 2012, 2013). However, the potential neural mechanisms that support the improvement in motor performance have yet to be directly determined. While highly aerobically fit older adults show larger levels of interhemispheric inhibition as compared to a sedentary age matched cohort (McGregor et al., 2011), it has yet to be determined if an aerobic exercise intervention can improve interhemispheric inhibition (in addition to motor performance) in previously sedentary individuals.

The current investigation enrolled 12 reportedly sedentary older adults (60+ years) into an intervention with two arms: a) an aerobic exercise condition and b) a stretching control condition. Each arm lasted 12 weeks and participants engaged in both conditions in a crossover design after being randomized into either the aerobic or stretching condition at program outset. Assessments of aerobic capacity, upper extremity performance, functional magnetic resonance imaging and transcranial magnetic stimulation were performed at program outset and after each 12-week study arm (pre-post1-post2).

After the aerobic exercise condition, all participants showed improved VO2peak, but despite a consistent exercise protocol across theenitresample, participants exhibited differential VO2 performance characteristics. The results of the study show that participants with initially low levels (<20 ml/min/kg VO2; n = 6) of cardiovascular fitness (VO2 peak) showed significant increases in interhemispheric inhibition in addition to improved motor performance (reaction time, psychomotor speed and manual dexterity). After the same aerobic exercise intervention, individuals with higher levels of initial physical fitness (>25 ml/min/kg; n = 6) showed improved reaction times and psychomotor speed, but consistent levels of interhemispheric inhibition as compared to assessment prior to the aerobic arm. Interestingly, after the stretching condition, some participants did show improved VO2 peak, but exhibited no changes in motor performance or level of interhemispheric inhibition.

The results of this ongoing study indicate that increased aerobic activity increases motor performance and interhemispheric inhibition. However, this effect is dependent on parameters of fitness and activity level at the outset of training.

Poster F13: Improvements in Visual Search Contribute to Visuomotor Learning
Motor Rehabilitation

Christopher Perry[1], Tarkeshwar Sighn[1], Kayla Goins[1], Barbara Marebwa[2], Troy Herter[1]
[1]University of South Carolina, Columbia, SC, USA, [2]University of Trento, Trento, Italy

Introduction: Visual search is used to gather visual information by actively scanning the visual environment with eye movements (overt visual search) and peripheral vision (covert visual search). Previous studies have shown that visual search can improve with practice and expertise in motor skills is linked to efficient visual search. While these findings suggest that improvements in visual search may contribute to motor learning, previous research has not directly tested this hypothesis. Here we examine the extent to which improvements in visual search contribute to the acquisition of a novel visuomotor skill. **Methods**: Eighteen young adults (20-31 years old) practiced a bimanual visuomotor task (Object Hit and Avoid Task) using an upper-limb robotic device (KINARM Endpoint Lab, BKIN Technologies, Kingston, Canada). In this task, objects (eight distinct geometric shapes) moved towards the subjects who used virtual paddles displayed on each hand to hit away two target shapes (Targets; n = 200), and avoid hitting the six distractor shapes (Distractors; n = 100). Each task trial lasted approximately two minutes, and the shape, location, and movement speed of individual objects was varied randomly to ensure every task repetition was distinct. Subjects completed six repetitions of the task once a week for six weeks. Object shapes assigned to Targets and Distractors varied weekly. Eye and hand movements were recorded to investigate the influence of visual search and limb-motor control on task performance. **Results**: Task performance, as measured by Targets hit and Distractors avoided, increased across all six weeks. Task performance improved rapidly during the first week (acute phase) followed by slower improvements over the over 5 weeks (chronic phase). We observed that acute improvements were more coupled to the number of targets that were overtly viewed with smooth pursuit and the number of targets that were successfully hit following pursuit (overt success). Furthermore, chronic improvements appeared to be more linked to increases in success avoiding distractors and hitting targets that were viewed peripherally (covert success). Improvements in task performance did not appear to be coupled to changes in limb motor control. **Conclusions**: These results provide direct evidence that improvements in visual search can contribute to visuomotor learning. Our data also shows that both overt and covert visual search contribute to motor learning during acute and chronic phases, respectively.

Poster F14: Comparing Three Dual-Task Methods and the Relationship to Physical and Cognitive Impairment in People With MS and Controls
MS

Megan Kirkland, Elizabeth Wallack, Samantha Rancourt, Michelle Ploughman
Memorial University, St. John's, Canada

Background: Dual-tasking (combining a motor and cognitive task (DT)) is a potential measure to detect subtle impairments in people with multiple sclerosis (MS). The optimal DT method and the relationship between DT performance and disability is not clear.

Objective: We aimed to compare three DT test methods in MS subjects compared to controls and to determine whether cognitive (Montreal Cognitive Assessment (MOCA)) or physical disability (Expanded Disease Severity Scale; EDSS) was related to DT performance.

Methods: We recruited MS participants with low disability (<3 EDSS) and high disability (≥3 EDSS) and age (±3 years), gender and education (±3 years) matched controls. Participants walked at self-selected (SS) speed on an instrumented walkway (Protokinetics, Havertown, USA), followed by three DT walks in randomized order; DT ABC (reciting every second letter of the alphabet), DT 7 (serially subtracting 7's from 100) and DT 3 (counting upwards, leaving out multiples and numbers that include 3). Velocity, cadence, stride width, stride length, variability of stride length (coefficient of variation) and percentage time in double support data were collected. DT values were subtracted from SS values to determine the change in performance (DIFF) for each gait parameter.

Results: Of the three DT methods, DT 7 resulted in the most consistent changes in performance in 3 of 5 gait variables. MS groups (high disability (6 females, 3 males) and low disability (7 females, 4 males)) and controls (=13) reduced walking velocity and cadence and shortened step length during DT with no significant differences between groups. MS subjects exhibited altered adaptation compared to controls in percentage double support and stride width. MS subjects significantly increased percentage double support during DT compared to SS (High Disability: SS 35.14±9.78, DT 40.40±12.97; Low Disability: SS 28.61±2.80, DT 34.71±5.87; $F=12.95$, $p<0.001$) while controls did not (SS 27.25±2.57, DT 30.48±8.84). Control subjects widened stride width by about 1cm (DIFF -1.76±2.75; $F=4.96$, $p<0.05$) while MS subjects did not. In MS subjects, gait variables at SS speed were correlated with physical disability (measured using EDSS) but not cognition (MOCA score). However, the change in performance during DT was correlated with cognition rather than physical disability (percentage double support DIFF $R=0.62$, $p=0.03$). Change in performance during DT was not correlated with cognition in control subjects.

Conclusions: Our results suggest that of the three methods tested, DT 7 (counting backwards by 7s) produced the most consistent decrements in performance. Stride length, velocity and cadence do not change differentially in MS subjects compared to controls but stride width and percentage time in double support during DT is uniquely altered in MS subjects. Double support is likely an important indicator of DT impairment since it correlates with cognitive (but not physical) impairment.

Poster F15: An Interprofessional Case Study: Training Health Profession Students in Clinical Exercise Therapy for People with Parkinson's Disease
Motor Rehabilitation

Theresa Sweeny, Rebecca States, Amerigo Rossi
Long Island University (LIU), Brooklyn, NY, USA

Educational institutions that provide clinical training to health profession students are either mandated or strongly encouraged to provide interprofessional education (IPE) opportunities for students. Successful integration of appropriate faculty, students and community participants into sustainable interprofessional clinical training is challenging. This case study aims to describe a successful IPE model involving people with Parkinson's disease (PWP) that is currently operational at a major NYC university, and to identify the strengths and limitations of the model. Our IPE model is adapted from Hirsh's (2011) recommendations for community based health care for PWP. It requires integration of four elements: (1) committed faculty members from various health professions; (2) community participants with mild to moderate idiopathic PD who consistently participate in exercise; (3) a university gym area with dual action resistance machines and space for group cardiovascular exercise; and (4) health profession students from diverse disciplines who enroll in an elective 3-credit course entitled *Exercise Training in Individuals with Parkinson's Disease (ETIPD)*. The ETIPD course was offered in academic year 2014-15 and will continue in 2015-16. Twenty-four students from the Departments of Athletic Training, Health & Exercise Science (ATHES), and Respiratory Therapy have participated in the course which is growing in popularity. The faculty currently includes professors from Physical Therapy, ATHES and Nursing who complete a physical assessment of the PWP three times a year in an on-going prospective cohort research project on the effectiveness of consistent exercise in PWP. The faculty also supervises the bi-weekly exercise sessions. One faculty member (A.R.) has primary responsibility for the didactic lectures in the course with the other professors presenting selected didactic modules. One faculty member (R.S.) heads the research efforts. The nurse faculty member (T.S) has had specialized training in Parkinson's disease sponsored by the Parkinson's Disease Foundation Edmond J. Safra Visiting Nurse Faculty Program. The PWP were referred to the exercise program through a community Parkinson' s support group. All sessions are offered for free to individuals with PD with the backing of the investigators' university and the community support group. The current cohort numbers 27 PWP who consistently exercise two times a week for 10 weeks a semester during the academic year. The strengths of the model include the attachment of the exercise sessions to a university sponsored course, the collegial and friendly atmosphere of the exercise sessions, the strong support of the university and the community Parkinson's group, and, perhaps most importantly, the strong conviction of all involved that consistent exercise slows the progression of Parkinson's disease and helps the participants maintain self sufficiency. The major limitation of the model is the challenge of presenting the full 20-session the summer module when the exercise sessions are not part of the ETIPD course.

Poster F16: Evidence for Interhemispheric Reorganization in Sensory Cortex Following Unilateral Upper Extremity Amputation in Humans
Motor Rehabilitation

Benjamin Philip[1,2], Scott Frey[1,2]
[1]Washington University, St. Louis, MO, USA, [2]University of Missouri, Columbia, MO, USA

Deafferenting injuries (e.g. limb amputation) lead to reorganization of the somatosensory cortex, but the functional relevance of these changes remains unknown. Classic work in primate somatosensory cortex (S1) identified immediate and precise reorganizational changes in S1 ipsilateral to deafferentation, following reorganization in contralateral S1 after small deafferenting injuries (Calford and Tweedale 1990). Furthermore, following unilateral rat forepaw deafferentiation, stimulation of the radial nerve from the intact side is associated with bilateral increases in the blood oxygen-level dependent (BOLD) response in S1, which appears to reflect disruptions in interhemispheric functional connectivity (Pawela et al. 2010). Human unilateral amputees exhibit bilateral increases in cortical sensorimotor hand areas during use of the intact limb (Bogdanov et al. 2012), but it remains unknown whether such effects depend on reductions in interhemispheric inhibition between motor and/or sensory regions.

In an effort to determine whether similar effects occur in human S1, we developed an fMRI-compatible system to deliver cutaneous stimulation to the fingers of the intact hand, as well as the left or right sides of the lower face, of 15 unilateral traumatic amputees and 28 healthy adults matched for age, gender, and handedness. Amputees showed greater activity than controls in left (ipsilateral to stimulation) S1 during stimulation of the intact left hand. Activity in the former hand territory showed no between-groups difference in response to facial stimulation, nor any statistically significant correlations with phantom limb pain or time since amputation. To our knowledge, this is the first demonstration of interhemispheric transfer of plasticity in human primary somatosensory cortex. This phenomenon may allow physicians to influence deafferented cortex (e.g. contralateral to a hand with nerve injury) by therapies targeting the intact hand or cortex, thereby opening new avenues toward rehabilitation of patients with unilateral upper limb disability.

Poster F17: Manual Asymmetry During a Bilateral Reach and Hold Task
Motor Rehabilitation

Elizabeth J. Woytowicz[1], Jill Whitall[1,2], Kelly Westlake[1], Robert L. Sainburg[3,4]
[1]University of Maryland School of Medicine, Baltimore, MD, USA, [2]University of Southampton, Southampton, England, UK, [3]Penn State Milton S. Hershey Medical Center and College of Medicine, Hershey, Pennsylvania, USA, [4]Penn State University, University Park, Pennsylvania, USA

We have previously characterized interlimb and interhemispheric asymmetries for unilateral coordination tasks. This work has led to a model of motor lateralization in which one hemisphere is specialized for impedance control that is robust to unstable environmental conditions, while the other hemisphere is specialized for predictive mechanisms that can specify efficient and smooth trajectories under stable environmental conditions. We hypothesize that these two specializations are distributed across the arms during everyday bilateral tasks that involve holding and manipulating, such as when holding a baguette with one hand to slice it with the other hand. We predict that each hand should demonstrate different specializations for each of these task elements during bilateral behaviors. In order to test this hypothesis, we designed an experimental equivalent of the hold and slice task. In this task, performed in a virtual environment with the unseen arms supported by frictionless air-sleds, the arms are connected by a spring, while one hand maintains its position at the origin of the task, and the other moves to a series of targets distributed across a range of directions. Thereby, the reaching hand is required to take account of the spring load to make smooth and accurate trajectories, while the stabilizer hand must impede the spring load to keep a constant position. Right-handed subjects performed each of two sessions of this task, with the order of the sessions counterbalanced between groups. In one session, the right hand reached while the left hand stabilized, and the second session the left hand reached while the right hand stabilized. Our very preliminary results indicate a hand by task component interaction, such that the right hand showed better reaching performance, with faster and smoother (Jerk) reaching. In contrast, the left hand stabilized better, showing less displacement than the right hand. These findings suggest that the specializations of each cerebral hemisphere for impedance and predictive mechanisms are expressed during bilateral interactive tasks, such as the reach and hold task. To date, this is the first demonstration of the dynamic dominance hypothesis within the context of an asymmetric bilateral task. Further, once evaluated in non-disabled adults, future investigations within patients post-stroke could provide knowledge for the development of novel functional bilateral rehabilitation approaches.

Poster F18: Modulating Transcallosal and Intrahemispheric Brain Connectivity with Transcranial Direct Current Stimulation (tDCS)

Neural Repair Mechanisms

Xin Zheng, Gottfried Schlaug
Beth Israel Deaconess Medical Center and Harvard Medical School, Boston, MA, USA

Background/Objective: Transcranial direct current stimulation (tDCS) can enhance or diminish cortical activity depending on the polarity of the stimulation. The inter-hemispheric disinhibition model after a stroke has been used to support the use of non-invasive brain-stimulation in stroke-lesioned brains, where decreased activity in one hemisphere can lead to uninhibited increased activity in the contralateral hemisphere which might interfere with the recovery process. This model has been developed mainly for the hand-motor system, where the effects of tDCS or transcranial magnetic stimulation on motor-evoked potentials (MEPs) and intra- and inter-hemispheric excitatory and inhibitory effects can be examined. Findings in the language/speech-motor system are less clear showing that both anodal and cathodal stimulation on either hemisphere can produce beneficial effects on language/speech-motor recovery. We aimed to examine physiological evidence of the inter-hemispheric disinhibition model in the language system through changes in inter- and intra-hemispheric connectivity due to tDCS.

Methods: Using an MR-compatible DC-Stimulator, we applied anodal stimulation to the right inferior frontal gyrus (IFG) regions of nine healthy adults while undergoing non-invasive cerebral blood flow imaging with arterial-spin labeling (ASL) MR imaging. Twenty additional subjects who underwent ASL-MRI without tDCS were used as a control group. The stimulation group underwent scanning for 26 minutes: the first 10 minutes were without stimulation (baseline), the next 8 minutes had the stimulation turned on (stim), and the final 10 minutes were without stimulation again (post-stimulation). All ASL images were then normalized and timecourses were extracted in regions of interest (ROIs), which were the left and right IFG regions, and the right supramarginal gyrus (SMG). Inter-hemispheric connectivity is taken as the correlation between left and right IFG and intra-hemispheric connectivity is taken as the correlation between right IFG and right SMG.

Results: The right, stimulated IFG timecourse showed a 10% increase in blood flow between baseline and the maximum of the stimulation phase, followed by a decrease in the post stimulation phase, where the average blood flow is still 3% higher than the baseline average. This elevated blood flow between post-stimulation and baseline is not seen in the other ROIs. Inter-hemispheric connectivity decreased significantly ($p<0.05$; r-scores from 0.67 to 0.53) between baseline and post-stimulation, while the intra-hemispheric connectivity increased significantly ($p<0.05$; r-scores from 0.74 to 0.81). The correlation scores did not change significantly in the control group over similar time intervals.

Conclusions: We showed that an MR-compatible DC stimulator and ASL-MRI can detect modulation of brain activity locally as well as in remotely connected brain regions. A decrease in inter-hemispheric connectivity with anodal stimulation, in conjunction with an increase in intra-hemispheric connectivity, suggests a more complex hemispheric interaction outside the motor system that might have to be taken into consideration when optimal stimulation paradigms are designed.

Poster F19: Right Hemisphere Structures Predict Post-Stroke Speech Fluency
Cognitive/Language Rehabilitation

Ethan Pani, Xin Zheng, Andrea Norton, Jasmine Wang, Gottfried Schlaug
Beth Israel Deaconess Medical Center and Harvard Medical School, Boston, USA

Objective: We sought to determine the contribution of (1) the right-hemisphere's speech-relevant white matter regions and (2) inter-hemispheric connectivity through the corpus callosum to speech fluency in the chronic phase of left-hemisphere stroke with aphasia.

Methods: We used fractional anisotropy (FA) to examine white matter underlying the right middle temporal gyrus (MTG), precentral gyrus (PCG), and pars opercularis of the inferior frontal gyrus (opIFG) as well as the corpus callosum (CC) and selected sub-regions thereof. We correlated FA values of these right-hemisphere and CC regions with speech fluency and efficiency measures and compared FA values of regions that significantly predicted speech measures with FA values of the same regions in healthy age-matched controls.

Results: FA values for the right MTG, PCG, and opIFG significantly predicted and were positively correlated with speech fluency. A multiple regression showed that the combination of right-hemisphere FA and left arcuate fasciculus lesion load (AF-LL), a previously identified biomarker of post-stroke speech fluency, improved our model for predicting speech fluency compared to AF-LL alone. FA of CC fibers connecting left and right supplementary motor areas (CC-SMA) was also correlated with speech fluency. FA of the right opIFG and PCG was significantly higher in patients than in controls, while FA of a whole CC ROI and the CC-SMA sub-region was significantly lower in patients.

Conclusions: Given the increase in FA observed in the right speech-motor homotops of patients relative to controls as well as the positive correlation between FA of the same regions and patient speech fluency outcomes, we hypothesize that compensatory, beneficial white matter reorganization occurred in the right hemisphere in patients. Lower FA values in the patient group CC ROIs are likely due to Wallerian degeneration and may have further contributed to right hemisphere changes.

Poster F20: Effectiveness of Modified Constraint Induced Movement Therapy in a Group Setting as Compared to Individual on the Quality and Quantity of Upper Extremity Movement Recovery After Stroke

Stroke

Rodrigo Rivas[1,2], Arlette Doussoulin[3], José Luis Saiz[4], Sarah Blanton[5]

[1]Universidad de La Frontera, Departamento de Especialidades Médicas, Temuco, Chile, [2]Clínica Alemana Temuco, Servicio de Medicina Física y Rehabilitación, Temuco, Chile, [3]Universidad de La Frontera, Departamento de Pediatría y Cirugía Infantil, Temuco, Chile, [4]Universidad de La Frontera, Departamento de Psicología, Temuco, Chile, [5]Rehabilitation Center, Emory University, Atlanta, USA

Background: Constraint-Induced Movement Therapy (CIMT) is a therapeutic strategy that has been show to improve the function of the upper limb affected by stroke. Although an extensive body of literature supports the positive impact of CIMT on neuroplasticity and the recovery of function, most research has evaluated an individual mode of delivery. However, evidence is limited for the application of CIMT protocol in a group setting.

Objective: To determine the effectiveness of a modified version of CIMT in a group setting as compared to individual, one-on-one basis on the quantity and quality of movement of the paretic upper limb.

Methods: Forty seven participants were analyzed and 36 patients were included. They were randomized into either a group or individual application of CIMT. The hemiparetic upper extremity quantity and quality of movement was evaluated using the self-reported, Motor Activity Log and each participant's clinical record at baseline, pre-treatment and post-treatment. *Inclusion Criteria*: Aged between 18 and 80 years, a single event of stroke confirmed by brain CT, with further evolution to 6 months the ability to sit independently, NIH Stroke Scale: 5 - 14 points, <2 points in the modified Ashworth scale, <4 points on the VAS, ability to perform a functional test of 20° of wrist extension and 10º in the extension of the fingers. *Exclusion Criteria:* Patients who may compromise sensory (visual-auditory), orthopedic limitations (use of cane), severe aphasia, failure to complete the inclusion criteria. The data were analyzed through an analysis of variance with a mixed factorial design 2x2. All patients signed informed consent.

Results: The median age 52.7±6.1 years, male were 66.7%, ischemic stroke were 63.9%, time since stroke 576±237 days. VAS: 1.55±1.18, modified Ashworth scale: 1.02±0.57. The median quantity and quality of movements (MAL) were in group pre-treatment (median): 1.79 and post- treatment (median): 3.09 and individual pre-treatment (median) 1.51, and post-treatment (median): 2.69. Subsequent to evaluate the groups after the intervention, it is important to note that while both methods improved the quantity and quality of movement, significant differences in favor of group mode with a value of $p = 0.04$.

Conclusion: This clinical trial provides evidence supporting the application of CIMT delivered in a group mode for 3 hours, to improve the performance of the paretic upper limb in daily activities. However the evidence is still limited in relation to this mode CIMT version.

Key words: Rehabilitation- Stroke-Upper Extremity

Poster F21: Is Structural Connectivity of Basal Ganglia Associated with Learned Non-Use in Chronic Stroke?

Motor Rehabilitation

Bokkyu Kim[1], Youngmin Oh[1,2], Richard Leahy[3,4], Justin Haldar[3,4], Nicolas Schweighofer[1,2], Carolee Winstein[1]

[1]Division of Biokinesiology and Physical Therapy at University of Southern California, Los Angeles, CA, USA, [2]Neuroscience Graduate Program at University of Southern California, Los Angeles, CA, USA, [3]Ming Hsieh Department of Electrical Engineering at University of Southern California, Los Angeles, CA, USA, [4]Brain and Creativity Institute at University of Southern California, Los Angeles, CA, USA

In those with mild to moderate stroke impairment, there can be a discrepancy between movement capability and daily use of the affected arm and hand. This is captured by the phrase, "he can, but does he?" This phenomenon may be a consequence of negative reinforcement resulting from affected arm use and positive reinforcement for less-affected arm use. The basal ganglia (BG), especially ventral striatum, are considered the neural reward center for reinforcement learning. Thus, the BG may have an important role in mediating the learned non-use phenomenon in chronic stroke. The primary aim is to investigate whether the structural connectivity of BG to other sensorimotor brain areas is associated with affected arm use. This study is part of a larger longitudinal Phase-I clinical trial of rehabilitation in chronic stroke (ClinicalTrials.gov ID: NCT 01749358). Individuals with mild to moderate motor impairment after stroke participated (N=24, average chronicity= 3.04 years). Structural brain images (T1-weighted MRI and DTI) were acquired, and processed using BrainSuite14a (http://brainsuite.org/). A total of twenty-four cortical or subcortical sensorimotor areas (Twelve regions of interests [ROIs] in each hemisphere) and a cerebellum ROI were chosen to construct a structural network. We calculated the Fractional anisotropy (FA) of each tractography between each ROI pair. A 25 X 25 FA matrix was generated to produce an undirected weighted graph. A weighted communicability graph was also computed from the raw FA matrix. Network metrics, including strength and degree, were calculated from FA and communicability graphs for each ROI. We calculated an asymmetric index (AI) of each network metric between an ROI and its homologous ROI in the other hemisphere. Motor Activity Log (MAL) was used to quantify the paretic arm use in daily activities. Linear regression analyses were used to test the relationship between connectivity metrics and MAL score. Significance level was set using Bonferroni correction for multipe comparisons (alpha=0.05/12=0.00417). There was no significant linear relationship between any network metrics and MAL score. However, the communicability strength AI (CSAI) of caudate nucleus showed the highest effect size on the MAL score among twelve CSAIs. 17% of variance in MAL score was explained by the caudate CSAI ($p=0.024$, Effect size [Cohen's f^2] = 0.21). Other ROIs' CSAI had smaller effect size than caudate CSAI on the MAL score (Cohen's $f^2 < 0.10$). This result provides partial support for our hypothesis that structural connectivity of BG is associated with affected arm use in chronic stroke. People with a higher caudate CSAI demonstrated less use of the affected arm in daily activities than those with a lower caudate CSAI. Future work should test whether a reduced structural connectivity of ipsilesional caudate nuclei is predictive of learned non-use, or is simply the result of affected arm non-use.

Poster F22: Toward a Self-Calibrating Brain-Computer Interface for People with Tetraplegia
Motor Rehabilitation

Beata Jarosiewicz[1,2], Anish Sarma[1,2], John Simeral[2,1], Daniel Bacher[1], Jad Saab[1], Brittany Sorice[3], Christine Blabe[4], Sydney Cash[3,5], Emad Eskandar[3], Krishna Shenoy[4], Jaimie Henderson[4], Leigh Hochberg[2,1]
[1]Brown University, Providence, RI, USA, [2]Dept. of VA Medical Center, Providence, RI, USA, [3]Massachusetts General Hospital, Boston, MA, USA, [4]Stanford University, Stanford, CA, USA, [5]Harvard Medical School, Boston, MA, USA

Brain-computer interfaces (BCIs) aim to restore communication and independence to people with severe motor disabilities by translating decoded neural activity directly into control of a computer cursor. However, nonstationarities in recorded brain activity can degrade the quality of neural decoding over time. Periodically interrupting ongoing use of the BCI to perform decoder recalibration tasks is time-consuming and impractical. In the ongoing pilot clinical trial of the investigational BrainGate2 Neural Interface System, we previously showed that typing performance in a self-paced, neurally controlled point-and-click communication interface can be maintained for hours, despite underlying signal nonstationarities, without requiring the user to pause to perform disruptive calibration tasks. This was accomplished using 3 innovations that address different aspects of neural signal nonstationarities: feature mean and variance tracking, decoder output bias correction, and retrospective target inference-based (RTI) decoder calibration, which uses data acquired during practical, ongoing BCI use to recalibrate the decoder. The current study extends self-calibration of the BCI to multiple days. On day 1, a BrainGate participant diagnosed with amyotrophic lateral sclerosis (ALS) (participant T6) performed the standard "center-out" decoder calibration task with presented targets, and then proceeded to self-paced typing. Then, on days 3, 5, 14, 35, and 42, with the aid of feature tracking and bias correction, the participant was able to proceed directly into self-paced typing using the previous session's last directional and click decoders. The decoders were updated periodically over the course of the day using RTI decoder calibration, without ever requiring the participant to perform explicit calibration tasks again after day 1. By eliminating the need for the user to perform daily calibration tasks with prescribed targets, despite nonstationarities in the underlying neural signals, this approach advances the potential clinical utility of intracortical BCIs for individuals with severe motor disability.

Poster F23: Imperceptible Random Vibration Applied to Wrist Skin Increased EEG Evoked Potential for Fingertip Touch

Sensory Rehabilitation

Na Jin Seo[1], Kishor Lakshminarayanan[2], Brian Schmit[3]

[1]Medical University of South Carolina, Charleston SC, USA, [2]University of Wisconsin-Milwaukee, Milwaukee WI, USA, [3]Marquette University, Milwaukee WI, USA

The objective of this study was to investigate if cortical activity for sensing touch stimuli on the fingertip is affected by imperceptible white-noise vibration applied to wrist skin. Recent studies have demonstrated that fingertip tactile sensory thresholds improved with continuous, imperceptible, white-noise vibration applied to different locations in the upper extremity such as wrist, forearm, dorsum of the hand, or base of the palm in healthy adults as well as chronic stroke survivors. As such, vibration can be used to manipulate sensory feedback and improve dexterity, particularly during neurological rehabilitation. Nonetheless, the neurological bases for remote vibration enhanced sensory feedback are yet poorly understood. This study examined how imperceptible random vibration applied to the wrist changes cortical activity for fingertip sensation in healthy adults using electroencephalogram (EEG). We employed somatosensory evoked potential to assess peak-to-peak evoked response to light touch of the index fingertip with applied wrist vibration versus without. The peak-to-peak somatosensory evoked potential in response to fingertip touch significantly increased ($p < .05$). In addition, increased neural recruitment of the somatosensory, motor, and premotor cortex with wrist vibration was observed, corroborating an enhanced cortical-level sensory response motivated by vibration. It is possible that the cortical modulation observed here is the result of the establishment of transient networks for improved perception. This study results support the modulation of cortical-level of somatosensory processing using remote imperceptible vibration, providing the neurobiological basis for its further use in rehabilitation.

Poster F24: From Noise to Music: Using Bayesian Statistical Parameter Estimation to Model Intra-Individual MEP Variability Before and After TBS for More Dynamic Biomarkers of Plasticity.
Stroke

Rachel Wurzman[1], Denise Harvey[1,3], Olufunsho Faseyitan[1,2], Daniela Sacchetti[1,2], Roy Hamilton[1,2]
[1]Laboratory for Cognition and Neural Stimulation, University of Pennsylvania, Philadelphia, PA, USA, [2]Department of Neurology, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA, USA, [3]Moss Rehabilitation Research Institute, Elkins Park, PA, USA

Continuous theta burst stimulation (cTBS), an inhibitory subtype of repetitive transcranial magnetic stimulation (rTMS), is thought to induce plasticity in the stimulated cortical region and thus is frequently investigated as a treatment for neural injury. Cortical excitability and neuroplastic changes therein are measured by assessing increases or decreases in the mean amplitude of motor evoked potential (MEPs), the motor response to TMS. However, the therapeutic utility of rTMS (including cTBS) has been curtailed by a high degree of variability in responses to repetitive stimulation, even among healthy individuals.[1] Despite advances in understanding several factors contributing to inter-individual variability in the rTMS response, much less is known about the variability of MEP amplitudes within individuals, which may itself constitute a dynamic factor affecting the induction of plasticity. A more precise characterization of the intrinsic variability of MEP amplitudes during collection may add a valuable new dimension to hierarchical models predicting individual neuroplasticity responses to rTMS.[2]

This study used Bayesian Data Analysis (BDA) methods to explore the possibility that the induction of plasticity may be accompanied by changes in the shape of the distribution of sampled MEPs within a block, independently of changes to mean MEP amplitude. To enable simultaneous estimation of multiple descriptive parameters for sets of collected MEPs besides the mean (i.e., mode, spread, normality, and skewness), we employed Bayesian statistics to estimate parameter values and examine changes in the distributions of sampled MEPs peak-to-peak amplitudes collected before versus after cTBS. 30-35 MEPs were obtained from the right dorsal interosseous muscle of 31 healthy individuals using single-pulse, aperiodic TMS to motor cortex (M1). TMS pulse-strength levels were individually determined as the ratio of percent machine output required to elicit 1mV MEP amplitudes to resting motor threshold (rMT), and remained constant throughout the experiment. After baseline MEP collection, cTBS was administered for 40s (50-Hz triplets delivered at 5-Hz; 80% active motor threshold), followed by post-stimulation MEP blocks sampled at 0-min, 20-min, and 30-min.

Our results suggest that shape of the distribution of MEP amplitudes might be a dynamic variable in itself. For example, MEP amplitudes were not normally distributed and at baseline, and shape parameters (spread, normality, skewness) varied as a function of TMS pulse-strength, but not the mode. Following cTBS, TMS pulse-strength no longer predicts distribution shape parameters, which instead appeared to vary as a function of the mode MEP amplitude in a subset of subjects. Importantly, BDA does not assume that the data are normally distributed a priori. Rather, it precisely estimates central tendency and shape parameters without discarding "outlier" values, which are often eliminated for statistical expediency despite being potentially meaningful datapoints.[3] Accordingly, BDA outputs more faithful representations of intra-individual MEP variability for integration into inter-individual variability predictions.

Poster F25: Paired Brain and Spinal Cord Stimulation to Strengthen Corticospinal Responses
Motor Rehabilitation

Asht Mishra[1], Disha Gupta[1], Ajay Pal[1], Jason Carmel[1,2]
[1]Burke Medical Research Institute, White Plains, NY, USA, [2]Weill Cornell Medical College, New York, NY, USA

Spinal epidural stimulation has emerged as a powerful tool to raise the excitability of spinal cord circuits and to strengthen voluntary movement after injury. We sought to augment excitability of the corticospinal motor tract by pairing stimulation of its origin in motor cortex with stimulation of its end in the cervical spinal cord. All of the experiments were conducted in intact, anesthetized adult rats. We measured excitability of the motor system by electrically stimulating motor cortex and recording EMG in the contralateral biceps muscle. We created response curves by stimulating cortex at increasing intensity and compared curve under different conditions. We delivered epidural stimulation on the dorsum of the cervical spinal cord. We conducted 3 experiments. In the first experiment, we measured the effects of tonic 40Hz spinal epidural stimulation on EMG responses. We hypothesized that, like lumber epidural stimulation, tonic cervical spinal cord stimulation would augment EMG responses in a manner dependent on the intensity, polarity, and stimulation location. Indeed, tonic stimulation directed at the cervical enlargement produced robust augmentation of EMG with both cathodal and biphasic stimulation that increased with intensity. In the second experiment, we hypothesized that a single pulse of spinal epidural stimulation at discrete intervals after cortex stimulation would augment EMG responses. Latency was a crucial determinant, with 11ms being optimal. This timing coincides with the timing of the spinal cord dorsum potential recorded in the cervical cord after motor cortex stimulation, suggesting synergistic effects of corticospinal and large diameter sensory afferent stimulation. Finally, we asked whether repeatedly pairing of cortex and spinal cord stimulation at the optimal latency would induce learning in the spinal cord. We created a baseline response curve and also measured the spinal stimulation necessary to provoke EMG responses. We then delivered motor cortex stimulation followed 11 ms later by a single biphasic spinal cord pulse and repeated this every 2 seconds for 5 minutes for a total of 150 paired stimuli. We recorded a response curve and spinal thresholds immediately after the pairings and every 10 minutes thereafter. Paired stimulation caused a dramatic (>100%) increase in motor responses and the spinal threshold also decreased. Thus, we demonstrate plasticity in the intact corticospinal motor tract by repetitive pairing of brain and spinal cord stimulation that occurs at the level of spinal cord.

Poster F26: Impaired Multi-Finger Synergies in Individuals with Multiple Sclerosis
MS

Daniela Mattos[1,3], Hang Jin Jo[1], Elisabeth Lucassen[1,2], Mark L. Latash[1]
[1]Pennsylvania State University, State College, PA, USA, [2]Pennsylvania State University-Milton S. Hershey Medical Center, Hershey, PA, USA, [3]University of Delaware, Newark, DE, USA

Multiple sclerosis (MS) is a demyelinating disease of the central nervous system that can result in impaired hand function. An important component of everyday hand actions is to ensure controlled stability of the combined action by a set of digits. We investigated multi-finger synergies stabilizing total force during a pressing task in twelve participants with mild and moderate MS and 12 age- and gender-matched control subjects. All subjects were tested during performance with their dominant and non-dominant hands. The subjects produced an accurate constant force level by pressing with four fingers on individual force sensors followed by a self-paced force pulse into a target. Finger inter-dependence (enslaving, E) was quantified using ramp force tasks performed by each finger. The uncontrolled manifold approach was used to compute a multi-finger synergy index during steady state and changes in this index (anticipatory synergy adjustments, ASA) in preparation to the force pulse. The MS group showed significantly lower maximal finger forces for both hands and higher enslaving among fingers when the lateral fingers (index and little fingers) were the task fingers. The MS group was also slower as compared to controls in the time to force peak. MS subjects showed significantly lower synergy indices than the controls during the steady-state phase and also demonstrated smaller and delayed ASA in preparation to the force pulse. These findings indicate that MS affects several aspects of multi-finger coordination including lower finger individuation, weaker force-stabilizing synergies, and decreased anticipatory adjustments in preparation to a quick action. These changes could be related to the impaired hand function observed in this population. Given that similar synergy changes are observed in patients with Parkinson's disease and multi-system atrophy, additional analysis is needed to explore possible differences in the indices of synergy in MS subjects with involvement of different pathways within the central nervous system.

Poster F27: Training a Complex Arm Skill Transfers to Improved Simple Reaching Tasks and Modulates Corticospinal Excitability in Patients With Stroke
Motor Rehabilitation

Nazaneen Zahedi, Robert McGrath, Shailesh Kantak
Moss Rehabilitation Research Institute, Elkins Park, PA, USA

Motor skill training involves acquiring novel movement capabilities through practice that leads to an improvement in the speed-accuracy tradeoff function, akin to acquiring real-world skills. Recent evidence indicates that skill learning is behaviorally and neuroanatomically distinct from motor adaptation and sequence learning. In this study we investigated the practice effects of a complex arm motor skill on change in speed-accuracy tradeoff (learning) as well transfer to a simpler functional reaching task. In a subset of patients, we explored the neural mechanisms of skill learning using transcranial magnetic stimulation (TMS). Specifically, we assessed the pre-post change in TMS-evoked recruitment curve and transcortical inhibition targeting the paretic triceps brachii. Participants with moderate stroke (n=10) practiced a complex motor task the goal of which was to navigate a cursor with their paretic arm through a virtual track as fast as possible without crossing the borders of the track. Performance changes during practice were characterized by improvements in accuracy while practicing within the prescribed movement time ranges. Learning was indexed by changes in the speed-accuracy tradeoff function measured at baseline, a day and approximately a month after practice ended. To assess the transfer to a non-practiced task, we examined the pre-post changes in goal-directed reaching to three different targets placed in front of the patient. All patients improved their performance on the practiced task. Following practice, there were improvements in the speed-accuracy tradeoff function that were retained over a month. Importantly, there was a significant improvement in the performance and control of non-practiced functional reaching task as evidenced by reduced movement times, higher peak velocities and shorter time-to-peak velocities after practice. Improved motor control was also reflected in improved efficiency indicated by decrease in the number of submovements during execution of the practiced as well as the non-practiced task. Neurophysiological data indicated an increase in the corticospinal excitability and decrease in transcallosal inhibition with training. Patients with stroke demonstrate improved performance and control of the trained paretic arm following practice of a complex arm motor task. This improved performance is accompanied by changes in the corticospinal and interhemispheric mechanisms. The most novel finding of our study is that learning of the complex task transfers to improved performance on an untrained simpler task. These findings have significant clinical implications suggesting that complex task practice may be helpful in driving performance and control improvements for simple tasks, particularly if the two (complex and simple tasks) share similar control processes. Corticospinal and interhemispheric changes likely underlie the efficient motor performance.

Poster F28: Effects of Metformin and Enriched Rehabilitation on Recovery Following Neonatal Hypoxia-Ischemia

Motor Rehabilitation

Sabina Antonescu[1,3], Matthew Jeffers[1,3], Jessica Livingston-Thomas[1,3], Cindi Morshead[2], Dale Corbett[1,3]

[1]University of Ottawa, Ottawa, Canada, [2]University of Toronto, Toronto, Canada, [3]Canadian Partnership for Stroke Recovery, Ottawa, Canada

Neonatal hypoxia-ischemia (HI) is one of the most common causes of mortality and morbidity in children, often leaving survivors with profound physical and cognitive disabilities. Effective treatments capable of supporting long-term recovery and reducing the severity of these disabilities are needed. Previous research using adult animal models of stroke has shown that metformin, an antidiabetic drug, promotes neurogenesis, oligogenesis and angiogenesis to enhance motor and cognitive function following injury. This study aims to determine whether metformin, enriched rehabilitation (ER) or a combination of the two could provide a clinically relevant therapeutic option for enhancing motor function following neonatal HI.

At post-natal day (PND) 7, Sprague-Dawley rats were assigned to two groups: sham (n=7) or hypoxia-ischemia (n=22). The Rice-Vannucci model was used to induce unilateral injury, in which HI animals had their left carotid artery permanently ligated prior to being placed in a hypoxia chamber (8% O2) for 90 minutes. At weaning (PND 21), animals assigned to ER were housed in an enriched environment and received reach training for 4 weeks. All other animals were standard housed. Once weaned, pups received subcutaneous metformin (200mg/kg/day) or saline injections for 4 weeks. Motor function was assessed pre- and post-combined therapy using the following tests: ladder-walking, adhesive-strip removal and Montoya staircase.

Following four weeks of treatment, hypoxia-ischemia animals receiving ER made 45% fewer errors with their impaired forelimb and 17% fewer errors with their impaired hindlimb on the ladder-walking test compared to standard housed HI animals. ER animals also displayed a decreased latency to contact the adhesive strip on their impaired forelimb. In addition, animals receiving either metformin or enriched rehabilitation showed enhanced motor learning on the Montoya staircase.

In conclusion, enriched rehabilitation promoted motor recovery following HI, while both ER and metformin accelerated acquisition of a skilled reaching task. Work in progress is examining the effects of metformin and enriched rehabilitation on cognitive function following HI.

Poster F29: Effects of Limb Non-Use on Resting Functional Connectivity
Motor Rehabilitation

Alex Carter, Kristi Zinn, Xin Hong
Washington University School of Medicine, Saint Louis, MO, USA

Background: Upper limb weakness is common after stroke, and in the acute phase results from direct damage to the sensorimotor network. However, in the subacute and chronic phases, learned non-use might lead to secondary brain reorganization and further impairment. To gain insight into brain reorganization after limb non-use, functional connectivity (FC) was analyzed using resting state (rs) functional magnetic resonance imaging (MRI) before and after arm immobilization (AI) in healthy subjects. We hypothesized that rsFC is driven in part by a history of coactivation between brain regions. This hypothesis predicts that reduced activity in the motor system will be associated with specific decreases in rsFC between regions involved in reaching, grasping and motor control.

Methods: Thirteen young healthy subjects wore a shoulder immobilizer that prevented shoulder/arm/wrist extension and flexion most of the day and night for two weeks. Motor performance was assayed before and after immobilization with grip strength, nine hole peg test (NHPT) and finger tapping tasks. RsFC MRI was obtained pre and post immobilization to analyze sensorimotor network reorganization using a seed based analysis. Seeded regions of interest (ROI) included M1, SMA, PMd, putamen, thalamus, insula and multiple regions in posterior parietal cortex important in reaching (superior parieto-occipital sulcus) and attention (intraparietal sulcus). Single pulse transcranial magnetic stimulation (TMS) was used to determine a laterality index of motor cortex excitability between the hemispheres.

Results: AI led to a reduction in grip, NHPT and finger tapping of the left hand. In AI responders, rsFC was decreased between multiple ROIs including the putamen, precuneus, dorsal medial superior parietal lobe, and regions in the posterior parietal cortex involved in reaching and attention. Some increases in rsFC were seen in the right insula. A secondary whole-brain voxel-wise analysis, showed clusters of decreased connectivity between motor and parietal cortex consistent with dorsal attention and default mode resting state networks. Changes in interhemispheric rsFC between left and right motor cortex were correlated with changes in the laterality index of cortical excitability.

Discussion: Two weeks of AI led to significant changes in rsFC between frontal, subcortical and parietal regions known to play a role in planning and execution of arm movements. These changes could represent the neural correlates of learned non-use. The rsFC changes were not purely decreases suggesting that rsFC may not be driven solely by the amount of brain co-activity. Decreased rsFC has been reported with some forms of learning. Adapting to immobilization may involve a degree of motor learning. Therefore we cannot say conclusively that the changes in FC are purely maladaptive or due to non-use. In addition, limb immobilization may lead to reorganization within brain regions beyond the sensorimotor network including regions involved in planning and attention.

Poster F30: Short-Term Practice Effects Predict Longer-Term Upper Extremity Motor Learning in Older Adults With and Without Mild Cognitive Impairment

Motor Rehabilitation

Sydney Schaefer[1,2], Jeffrey Nielsen[1], Tyson Lumbreras[1], Kevin Duff[2]

[1]Utah State University, Logan, UT, USA, [2]University of Utah, Salt Lake City, UT, USA

While dose-response studies have suggested that larger doses of neurorehabilitation lead to better outcomes, there may be value in using shorter-term 'practice effects' to predict responsiveness to a clinical intervention. Recent work in older adults has demonstrated the utility of practice effects after one week of cognitive training, but has focused primarily on explicit memory tasks. We have begun exploring motor tasks that require implicit memory formation (i.e. procedural learning) that may, in concert, provide a more comprehensive assessment of cognitive function in older adults. The purpose of this study was to compare short-term improvements due to practice on a complex upper extremity motor task between samples of young (n=28) and older (n=29) adults. Within the older adult sample, 55% had cognitive scores below the normative cutoff (Montreal Cognitive Assessment, MoCA). All subjects were free of known neurological or musculoskeletal conditions. We hypothesized that over four practice trials within a single session, the rate of improvement would be greatest for the young adults and smallest for the older adults with cognitive impairment. Performance on each trial was measured as the time to complete the motor task, with shorter times indicating better performance. Analyses of variance (ANOVAs) and correlation coefficients showed, however, that all three groups had comparable rates of improvement, despite having significantly different baseline performances on the motor task itself ($p<.0001$). The young adults completed trial 1 in the shortest amount of time, and the cognitively-impaired older adults took the longest. To test the sensitivity of our motor task in discriminating age and cognitive status, we fit Receiver Operating Characteristic (ROC) curves to baseline data (trial 1) as well as improvement data (normalized change from baseline to trial 4). Although ROC curves moderately discriminated young and impaired subjects based on their baseline performance (AUC = 0.75), they were unable to do so above chance based on the *amount of improvement from baseline* (AUC = 0.55). Collectively our data showed comparable improvement after four practice trials, regardless of age or cognitive status. Moreover, these short-term practice effects were significantly related to 1) the amount of learning achieved by the older adults after completing a much larger dose of practice (150 trials over 3 days) (Spearman's r=0.49; $p=.018$), and 2) the amount retained one month later (r=0.41; $p=.05$). We do acknowledge that the MoCA is a gross measure of global cognition, and does not specifically test implicit memory; thus, despite some of the older adult group presenting with cognitive impairment, they may have relatively intact implicit memory function. Nevertheless, these results provide preliminary evidence of how short-term practice effects may have predictive value in determining responsiveness to longer-term procedural learning interventions in neurorehabilitation.

Poster F31: **Differential Effects of Moderate and High Intensity Exercise on Corticomotor Excitability, Intracortical Inhibition and Intracortical Facilitation**
Motor Rehabilitation

Miriam Rafferty[1,2], Samantha Keil[2], Daniel Corcos[1]
[1]Northwestern University, Chicago, IL, USA, [2]University of Illinois at Chicago, Chicago, IL, USA

Background: Single bouts of aerobic cycling have been shown to have an immediate effect on corticomotor excitability, intracortical inhibition, and intracortical facilitation measured with transcranial magnetic stimulation (TMS). The purpose of this study was to determine whether an immediate bout of treadmill walking led to changes in TMS measures, and whether the response was sensitive to intensity dose. Covariates such as prior experience with high intensity exercise and baseline value of TMS measures were examined. Methods: Twenty-two participants exercised for 30 minutes on two, non-consecutive days. They walked on an incline at a brisk pace with the intensity targeted to 65% and 80% of age-predicted maximum heart rate. They were tested with single and paired pulse TMS before and after exercise. Results: Following moderate intensity treadmill walking, corticomotor excitability increased as measured by the motor evoked potential (MEP) amplitude, intracortical inhibition increased demonstrated by a lengthened cortical silent period (CSP) duration, and short-latency intracortical facilitation (SICF) increased ($p < 0.05$ for all). Following high intensity walking the responses were reversed: corticomotor excitability decreased as demonstrated by increased stimulus intensity required to elicit a 1 mV MEP, long-latency intracortical inhibition (LICI) decreased, and SICF decreased ($p < 0.01$ for all). There were no changes in short-latency intracortical inhibition following either intensity walking. These differences were not mediated by past participation in high intensity exercise. Discussion: The response following moderate intensity treadmill walking was a net gain in excitability and facilitation, which could put the brain into a more plastic state. In contrast, the reversed effect of high intensity treadmill walking could indicate a decrease in neural plasticity. The apparent contrast between intensities could be due to proposed U-shaped relationships between exercise intensity and specific neurotransmitter activation, cortisol, or cerebral blood flow.

Poster F32: Reduced Ankle Muscle Co-Contraction after Robot-Guided Therapy in Children with Cerebral Palsy

Motor Rehabilitation

Yi-Ning Wu[1], Yupeng Ren[2,3], Li-Qun Zhang[2,3]

[1]University of Massachusetts Lowell, Lowell, MA, USA, [2]Rehabilitation Institute of Chicago, Chicago, IL, USA, [3]Northwestern University, Chicago, IL, USA

Background and Aim: The majority of children with CP have gait deviations that lead to higher energy expenditure and impact their quality of life. More than half of the gait deviations in children with CP involve impaired ankle motor control as a result of spasticity, contracture, muscle weakness, disturbed neural drives and so on. Combined stretching and active movement training through robot-guided therapy has demonstrated the treatment efficacy in children with spastic CP. The improvement seen in the previous study might be due to many factors such as reduced spasticity, reduced muscle stiffness, and increased extensibility of calf muscle. However the effect of robot-guided therapy on the muscle activation pattern hasn't been reported. The muscle activation pattern can reflect the outcome on central neural drive. This abstract reports changes of dorsi-/plantar-flexor co-contraction during active ankle dorsiflexion after the robot-guided therapy.

Participants: Ten children with spastic CP (five girls, five boys, aged 8 y 3 mo) were recruited. All of the recruited children were above Gross Motor Function Classification System (GMFCS) level III (able to walk independently with our without assistive device). All had considerable ankle spasticity at the time of recruitment. None of them received the botulinum toxin type A injection six months prior to and during the study.

Methods: An 18-session robot-guided therapy program including passive stretching and active movement training were carried out in a research laboratory within a rehabilitation hospital. Each session consisted of ten minutes of passive stretching, twenty minutes of active movement training followed by ten minutes of passive stretching. Before and after robot-guided therapy, muscle activations of tibialis anterior (TA) and gastrocnemius (GM) during active ankle dorsiflexion were recorded by the surface electromyography (EMG). The amplitude of the EMG linear envelope (LE) of each muscle was normalized to the muscle's corresponding EMG amplitude under the maximum voluntary isometric contraction. The co-contraction index (CCI) was derived by the ratio of GM EMG LE amplitude to TA EMG LE amplitude and was presented in percentage. The higher percentage stands for higher co-contraction. Passive ROM (PROM), active ROM (AROM), dorsiflexor and plantarflexor muscle strength, Selective Control Assessment of the Lower Extremity, and functional outcome measures (Pediatric Balance Scale, 6-minute walk, and Timed Up-and-Go) were used to examine the clinical outcomes.

Results: The clinical outcomes were significantly improved after robot-guided therapy as presented in the previous study. The CCI reduced significantly after the robot-guided therapy program from 11.6% (SD= 8.85%) to 9.3% (SD=9.3) with p= 0.04.

Conclusions: The findings of reduced muscles co-contraction suggest that the improvement seen in the clinical outcome might be partly due to improved motor control. The participants could activate the targeted muscle (TA) more efficiently with less disturbances of the antagonist (GA) co-contraction.

Poster F33: Comparing Mirror Visual Feedback and Actual Visual Feedback Post Stroke
Motor Rehabilitation

Qiang Lin[1,2], Viswanath Aluru[1], Daniel Geller[1], David Rhee[1], Sravani Mudumbi[5], Priya Bolikal[4], Eric Altschuler[4], Ying Lu[3], Preeti Raghavan[1]
[1]New York University School of Medicine, New York, USA, [2]the First Affiliated Hospital of Sun Yat-sen University, Guangzhou, China, [3]NewYork University, New York, USA, [4]University of Medicine and Dentistry of New Jersey, New Jersey, USA, [5]Johns Hopkins University, Maryland, USA

Mirror visual feedback (MVF) is a non-invasive technique where visualization of movements of the unaffected side can potentially stimulate neural circuits on the affected side for enhanced motor performance. MVF has been used in the rehabilitation of upper limb function after stroke; however the mechanisms by which it affects motor control are not yet fully understood. Thirteen subjects between 27-63 years (mean 45.3, SD =13.2), at least 6 months post stroke performed wrist extension movements using a custom-made wrist trainer in two separate experiments. In the unimanual experiment, subjects moved their affected wrist with (1) MVF provided using a mirror reflection of the movements of the unaffected side on the screen in front of them and (2) actual visual feedback (AVF) by looking at the affected side moving. In the bimanual experiment, subjects moved both wrists simultaneously with (1) MVF provided using mirror reflection of the unaffected side in a mirror between the two arms, and (2) AVF by looking at the affected side moving. Motor impairment, wrist kinematics and surface EMG activity of the wrist extensors and flexors were measured. Due to large differences in the Fugl-Meyer scores and baseline wrist kinematics, the subjects were divided into high performance (n=7) and low performance (n=6) groups for further statistical analysis. During unimanual movements, the high performance group showed increased wrist extension with AVF compared to MVF, but used a feedback strategy where the deceleration time of wrist extension was increased. There was no significant difference in EMG activation or co-activation across the wrist flexors and extensors. On the other hand, the low performance group showed no significant differences in wrist extension between AVF and MVF, but also used a feedback strategy with AVF and showed increased wrist flexor, extensor and flexor-extensor co-activation compared with MVF. During bimanual movements, the high performance group used a feedforward strategy with MVF with higher acceleration times compared with AVF, but no other differences in performance were noted. The low performance group, showed lower wrist flexor activation and co-activation with MVF compared to AVF. The results suggest that actual visual feedback from looking at the affected hand moving improves wrist extension using a feedback strategy in the high performance group, whereas mirror visual feedback reduces co-activation in the low performance group which may be helpful to promote easier movement in this group. It is necessary to stratify subjects based on their performance in order to understand motor control patterns and develop evidence-based personalized training strategies post stroke.

Poster F34: Discriminating Visuospatial Neglect from Proprioceptive Impairment using Robotics
Stroke

Janice E. Yajure[1,2], Jennifer A. Semrau[1,2], Troy M. Herter[4], Stephen H. Scott[3], Sean P. Dukelow[1,2]
[1]University of Calgary, Calgary, AB, Canada, [2]Hotchkiss Brain Institute, Calgary, AB, Canada, [3]Queen's University, Kingston, ON, Canada, [4]University of South Carolina, Columbia, South Carolina, USA

Visuospatial neglect commonly occurs after stroke and results in impaired attention to locations, objects and limbs in contralesional space. Neglect typically leads to increased recovery times and poorer outcomes following stroke. Typically, neglect is identified based on clinical impression which is supplemented with pen and paper assessments, such as the Behavioral Inattention Test (BIT). Our group has previously reported that a high percentage of stroke survivors who perform poorly on the BIT also perform poorly on robotic testing of proprioception. However, we have also seen a number of anecdotal cases of individuals with poor proprioception who appear to be have been misdiagnosed by clinicians as having neglect. We sought to compare the clinician's impression of the presence of neglect in acute stroke subjects, performance on the BIT and robotic proprioceptive testing. Determining specific impairments can guide therapists to deliver targeted interventions.

Hospital charts of 252 subjects with subacute stroke were reviewed to determine whether clinicians (physicians, occupational and physiotherapists) had identified neglect as a presenting symptom on their initial assessment. Subjects were assessed in the research laboratory using the conventional sub-tests of the BIT and underwent robotic assessment of position sense (PM: sense of limb location) and kinesthesia (KIN: sense of movement) on the KINARM exoskeleton . Failure on each of the robotic tests was determined via comparison to the 95% limits of normative control data.

Seventy subjects were determined by clinicians to have neglect versus 56 subjects that were identified as having neglect through the BIT. One-hundred twenty-six subjects failed PM, while 163 failed KIN. The majority of subjects that failed the BIT also had clinician identified neglect (C+, BIT+ N=40). However, 30 subjects identified by clinicians actually passed the BIT (> 129) (C+,BIT-). Many subjects who failed the BIT were not identified by clinicians (C-,BIT+, N=16). We found that nearly all subjects in the C+,BIT+ and C-,BIT+ groups had significantly impaired PM (C+,BIT+=90% N=36, C-,BIT+=75%, N=12) and KIN (C+,BIT+=98% N=39, C-,BIT+=100%, N=16). We found that many subjects in the C+BIT- group had significant proprioceptive impairments (PM=57%, N=17, KIN=73%, N=22). When we compared the proportion of C+BIT- subjects with proprioceptive impairments to those subjects with normal BIT and no clinician-identified neglect (C-,BIT- N = 166, PM=37%, KIN=52%), we found a 20% higher proportion of subjects failing proprioceptive tasks in the C+BIT- group.

We found that many individuals identified by clinicians as having neglect with negative testing on the BIT had significant proprioceptive impairments according to performance on robotic measures of proprioception. We question whether clinicians are misidentifying proprioceptive loss as visuospatial neglect. This speaks to the necessity for better and more sensitive assessments of post-stroke impairments.

Poster F35: Transcranial Direct Current Stimulation Lessens Dual Task Cost in People with Parkinson's Disease

Cognitive/Language Rehabilitation

Chad Swank, Jyutika Mehta, Christina Criminger
Texas Woman's University, Dallas, TX, USA

Background & Objective: Parkinson's disease (PD) progressively impairs individuals of cognitive and physical function including walking. Gait for people with PD degrades during motor-cognitive interplay (i.e. dual task conditions). Current management of people with PD improves motor symptoms but inadequately benefits cognitive function, indicating a necessity for novel treatment approaches. Transcranial direct current stimulation (tDCS), a form of noninvasive brain stimulation, may have therapeutic potential as it has demonstrated isolated facilitation of motor and cognitive processing in people with PD. Therefore, our purpose was to identify if application of bilateral brain hemisphere protocol of tDCS improved the ability to divide attention during walking in people with PD.

Design: Participants with PD between 50-80 years received two sessions of tDCS protocol (1 $tDCS_{active}$, 1 $tDCS_{sham}$) during "ON" times separated by 7 days. tDCS protocols were randomized and blinded to participants. Following each tDCS protocol, participants performed single and dual task gait. Gait conditions were randomized.

Setting: Texas Woman's University Human Neurophysiology lab.

Participants: Convenience sample of nine people with PD age 50-80 years.

Interventions: Single 20-minute session of bilateral tDCS (dorsolateral prefrontal cortex; left = anode, right = cathode) at 2mA and one sham session. Participants were seated without a concurrent task during the tDCS protocol.

Main Outcome Measures: Participants were assessed at baseline for disease severity [United Parkinson Disease Rating Scale (UPDRS)] and executive function [Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)]. Following each tDCS condition ($tDCS_{active}$, $tDCS_{sham}$), participants performed Timed Up and Go (TUG) single and dual task conditions (TUG_{alone}, TUG_{motor}, $TUG_{cognitive}$) and Parkinson's Disease Questionnaire - 39 (PDQ-39).

Results: Participants [UPDRS x=38.89 (range=20-60), RBANS x=82.56 (13%ile)] showed no significant differences on paired T-tests for TUG conditions (TUG_{alone} ($p=0.39$), TUG_{motor} ($p=0.41$), $TUG_{cognitive}$ ($p=0.15$)) or PDQ-39 ($p=0.32$). Gait velocity dual task cost for TUG_{motor} was 22.27% ($tDCS_{active}$) compared to 23.7% ($tDCS_{sham}$) and for $TUG_{cognitive}$ was 28.24% ($tDCS_{active}$) compared to 42.51% ($tDCS_{sham}$). Cognitive dual task cost for $TUG_{cognitive}$ was 13.92% ($tDCS_{active}$) versus 19.79% ($tDCS_{sham}$). Dual task cost was only minimally or moderately related to disease severity (UPDRS; $r = 0.049$-0.516) and cognitive performance (RBANS; $r = 0.058$-0.616).

Conclusions: Our bilateral tDCS protocol in participants with PD did not significantly improve dual task gait. However, dual task cost following $tDCS_{active}$ was decreased. Further investigation of our bilateral tDCS approach on dual task gait in people with PD with larger sample size appears warranted.

Poster F36: Characterizing Impairments in Digit Angular Excursion and Individuation in Different Shoulder Positions Post-Stroke

Motor Rehabilitation

Alvin Tang[1], Viswanath Aluru[1], Mohamed Hassan[3], Lauri Bishop[2], Joel Stein[2], Preeti Raghavan[1]

[1]New York University School of Medicine, New York, New York, USA, [2]Columbia University, New York, New York, USA, [3]New York University Physical Therapy, New York, New York, USA

The ability to move the fingers independently is necessary to perform everyday tasks such as typing, grasping objects of different shapes and playing music. A stroke invariably leads to impaired finger independence particularly for finger extension. It has been suggested that arm posture and orientation can affect finger independence. Here we characterize finger independence in the affected hand in subjects with chronic stroke and determine its relationship to arm posture. Thirteen subjects, 28-81 years, with chronic hemiparesis at least 6 months post-stroke participated in the study. The degree of upper limb motor impairment was assessed using the Fugl-Meyer Scale (FMS). Subjects were asked to perform three 15-second cyclical maximal flexion-extension movements of an instructed finger from the MCP joints of the affected and unaffected hands, while keeping all the other fingers as still as possible in three different shoulder positions: (1) shoulder neutral and elbow flexed to 90 degrees, (2) shoulder flexed to 90 degrees, and (3) shoulder abducted to 90 degrees. The forearm was supported in all three positions. The angular displacement, frequency and distance travelled by the fingers were recorded using an instrumented glove (Cyberglove, Immersion Corp., San Jose, CA). We computed the frequency of finger excursions, the extent of finger flexion and extension, and the individuation index which reflects the degree to which the instructed finger moves while keeping all the other fingers still. The metrics were compared across the three shoulder positions. We found that the frequency of finger excursions and the degree of flexion were greater in the shoulder neutral position across most subjects. The degree of finger extension and individuation varied across individuals: subjects with severe motor impairment (FMS<20) showed greater finger extension and individuation in the shoulder neutral position, whereas subjects with moderate motor impairment (FMS=20-50) showed higher finger individuation and/or finger extension in the shoulder flexed or abducted position. The results suggest that the effect of shoulder position on finger independence depends on the stage of recovery likely due to the effect of arm posture on potentiation of spasticity and synergy patterns. Using shoulder positions that inhibit spasticity may be helpful in training finger individuation and/or extension.

Poster F37: Statin Medication Use and Nosocomial Infection Risk in the Acute Phase of Stroke
Stroke

Douglas Weeks[1], Christopher Greer[1], Megan Willson[2]
[1]St. Luke's Rehabilitation Institute, Spokane, WA, USA, [2]Providence Sacred Heart Medical Center, Spokane, WA, USA

Background. Statins have immunomodulatory and peripheral anti-inflammatory properties that are independent of their lipid-lowering action. Whether these properties can reduce risk for developing post-stroke infection is debated in clinical literature.

Objective. To estimate the risk for developing nosocomial post-stroke infection based on treatment with statins in patients age 18 or older hospitalized for ischemic stroke.

Methods. In this retrospective cohort study, a consecutive sample of acute care hospital electronic medical records were analyzed. Patients were assigned to the exposed arm when statin use either preceded infection or statins were used, but no infection was reported. Patients not on statins during the hospital stay regardless of infection status and patients initiating statins after infection had occurred were assigned to the unexposed arm. The association of statins with incidence of infection was examined with binary conditional stepwise logistic regression (LR) when post-stroke infection risk factors, namely advanced age, sex, stroke severity, intubation, dysphagia, and presence of other immunomodulatory medications, were controlled. Cochran-Mantel-Haenszel (CMH) analyses examined the association of statin exposure and infection status within strata of each binary LR predictor variable that significantly increased odds of infection.

Results. Records for 1606 patients were analyzed: 1176 in the exposed arm and 430 in the unexposed arm. Infection developed in 18% of the statin exposed group and 35% of the unexposed group ($P < .001$). The adjusted odds from LR for development of infection given treatment with statins was .438 indicating that statins significantly ($P < .001$) reduced odds for developing nosocomial infection by 56% over no exposure to statins. CMH analyses revealed that statins significantly lowered risk for developing infection in males and females and patients with dysphagia. Statins did not significantly reduce risk of infection for patients intubated with either a nasogastric tube or endotracheal tube.

Conclusions. In patients with ischemic stroke and no additional procedure-related risk factors for infection, namely nasogastric intubation or endotracheal intubation, treatment with statins was associated with significantly reduced risk for development of nosocomial infection.

Poster F38: Use of the GesAircraft Video Game for Upper Limb Rehabilitation in Stroke: A Pilot Study

Stroke

David Putrino[1,2], Helma Zanders[1], Avrielle Rykman[1], Peter Lee[1], Luis Disla[3], Owais Naeem[3], Tanjin Panna[3], Dylan Edwards[1,2]

[1]Burke Medical Research Institute, White Plains, NY, USA, [2]Cornell University, New York, NY, USA, [3]GesTherapy, Inc, Brooklyn, NY, USA

Introduction: Stroke is the leading cause of permanent motor disability in the United States. In the chronic phase of stroke recovery (>6 months post-stroke) more than 60% of stroke survivors still suffer from serious limitations in upper limb functionality. However, this subset of stroke survivors rarely has access to motor rehabilitation at a sufficient intensity to produce meaningful clinical gains due to the cost and inconvenience of regular physical therapy sessions in a traditional clinical environment. Telemedicine is an emerging field that aims to use innovative technology to deliver an unprecedented standard of care to individuals in need. Here we pilot test the feasibility of a telemedicine system designed to improve upper limb function in stroke survivors.

Methods: Our group developed a digital game that utilizes the Leap Motion Controller, an accessible piece of motion-capture technology, to encourage upper limb exercise in stroke survivors. The digital game, called 'GesAircraft', was designed to train three axes of movement: wrist flexion/extension, wrist ulnar/radial deviation and forearm pronation/supination. GesAircraft is capable of automatically calibrating to each user's individual range of motion, allowing for therapy protocols to be personalized to individual ability. Ten stroke survivors who were at least 6 months post- hemorrhagic or ischemic stroke (Mean: 78.4 months; Range: 6-162 months), and with a wide range of upper limb impairment, as assessed using the Fugl-Meyer Assessment (FMA; Mean: 38.8 (17-56). Subjects engaged in 6 weeks of gamified therapy, at a frequency of three sessions per week, and a total of thirty minutes per session. Engagement and usability of the system was assessed using the System Usability Scale (SUS) the Physical Activity Enjoyment Scale (PACES). Following the protocol, the FMA by an independent assessing therapist: to determine whether upper limb impairment had decreased.

Results: Study participants found the system to have "Good" Usability (72±7.9), while clinicians rated the usability of the system as "Excellent" (80±10.2). Participants reported finding the intervention to be enjoyable, with an average response of 5/7 to PACES items. We found no correlation between PACES score and level of impairment. Participants gained 2.8 (±2.1) on the FMA post-therapy, which was determined to be a significant increase ($p<0.001$; one-sample t-test). A significant correlation was also found between increases in the FMA and the participant's PACES score (Spearman's $r^2 = 0.84$, $p < 0.002$).

Discussion: We have demonstrated a system that significantly decreases impairment in chronic stroke survivors following a moderate-intensity exercise protocol. The system is portable, and simple enough to be used independently in the home. The correlation between user enjoyment and treatment efficacy provides us with an interesting insight into how to optimize the efficacy of motor therapy in this population in the future.

Poster F39: Reactive and Voluntary Stepping in Individuals With Stroke: A Comparison Between Paretic and Nonparetic Leg Responses

Motor Rehabilitation

Chieh-ling Yang[1], Vicki Gray[1], Masahiro Fujimoto[2], Sandy McCombe Waller[1], Mark Rogers[1]
[1]University of Maryland Baltimore, Baltimore, MD, USA, [2]Ritsumeikan University, Kusatsu, Japan

Background: Fall risk after stroke is a major healthcare concern. Impaired lateral weight transfer between paretic (P) and nonparetic (NP) legs during reactive and voluntary stepping may disrupt balance stability and increase fall risk after stroke.
Objective: We compared the stepping responses of the P and NP leg during unexpected waist-pulls to the P and NP side versus cued voluntary stepping of the P and NP leg in individuals with chronic stroke.
Methods: Fourteen community dwelling individuals >6 months post stroke completed reactive and voluntary lateral step testing. For reactive lateral stepping, 24 trials of randomly-ordered unexpected waist-pull perturbations were applied to the subject (2 directions × 3 repetitions × 4 magnitudes). For voluntary lateral stepping, subjects were instructed to perform 10 trials of a single lateral step as fast as possible according to the direction of a light cue (2 directions × 5 repetitions). The main outcome measures were first step characteristics including step onset, step duration, normalized step clearance, normalized step length in the mediolateral (ML) and anteroposterior (AP) direction, normalized global step length, and normalized center of pressure (COP) velocity. Nonparametric tests were used for comparison of significance between the P and NP leg responses during reactive and voluntary stepping.
Results: During reactive stepping, subjects initiated steps with the NP leg 61 % of the time regardless of the pull direction. Compared to the lateral steps initiated with the NP leg, the P leg steps had a marginally lower clearance (P=0.068), longer ML step length (P=0.068), and shorter global step length (P=0.068). In contrast, during voluntary stepping, all subjects could generate a P voluntary lateral step, however step clearance (P=0.056), ML step length (P=0.026), and global step length were smaller (P=0.056). The AP step length was larger compared to NP stepping (P=0.011). Across the four conditions (reactive lateral steps initiated with P/NP leg and voluntary lateral steps initiated with P/NP leg), a significant difference was found in the first step duration (P=0.031). Post hoc analysis showed a significantly longer step duration in voluntary NP leg stepping compared to reactive NP leg stepping (P=0.046).
Conclusion: We have identified differences between P and NP leg responses during reactive and voluntary stepping in individuals post-stroke. This has implications for the development of rehabilitation interventions to prevent falls in this high risk group.

Poster F40: Towards Assessing Mobility in Parkinson's Disease Patients Using a Single 3D Sensor
Motor Rehabilitation

Luciano Nocera[1], Helen R. Bacon[2], Jiun-Yu Kao[1], Yu-Chen Chung[2], Yi-An Chen[2], Lorraine Sposto[1], Beth E. Fisher[2], Cyrus Shahabi[1], Carolee J. Winstein[2]
[1]Integrated Media Systems Center, University of Southern California, Los Angeles, CA, USA, [2]Division of Biokinesiology and Physical Therapy University of Southern California, Los Angeles, CA, USA

For number of disabilities, e.g., Parkinson's Disease (PD), optimized medication and rehabilitation plans require reliable and frequent mobility assessments. Current clinical scales, e.g., the Unified Parkinson's Disease Rating Scale (UPDRS) lack resolution and rely on subjective visual observation. Our Point of Care Mobility Monitoring (POCM2) system uses Kinect to monitor a patient who performs a standardized task. As such POCM2 has the potential to provide an objective assessment solution that can be deployed in the home. We discuss preliminary results of a study where POCM2 was used to characterize the medication state of 14 PD patients, as suggested by the observation that gait in persons with PD can be improved by medication. We report results of a dual-task walking task (i.e., walking in a figure-of-eight pattern while counting backward) for which the Kinect sensor was most accurate while the cognitive task introduces an additional challenge that accentuates the differences between on and off medication conditions. At each timestamp, we considered a subset of 15 nodes (head, neck, torso, shoulders, elbows, hands, hips, knees and feet) of the skeleton that Kinect produces in conjunction with the self-reported most affected side. Steps and strides were automatically segmented (we excluded turns and measurements on segments of the trajectory where the sensor did not have a good viewing angle). Subsequently, steps and strides were used to derive linear and angular kinematic measurements. In the process, post-processing was applied to recover left and right side of the body (Kinect assumes the person is facing the sensor), and limit the maximum extent of joints (Kinect does not constrain joint angles). Each variable was measured multiple times over the course of two trials and the average was used for the statistical analysis. The statistical analysis indicated that left step length and step length grouped by most affected side were both statistically significant ($p<0.05$). For least affected steps, standard deviation of most affected shoulder angle ($p=.003$), least affected shoulder angle ($p=.001$), most affected hip angle ($p=.009$) and least affected hip angle ($p=.002$), and for most affected steps, the average least affected hip angle ($p=.011$), standard deviation of most affected knee angle ($p=.008$), least affected shoulder angle ($p=.001$), most affected shoulder angle ($p=.008$), least affected hip angle ($p=.001$) and most affected hip angle ($p=.001$) were statistically significantly different. These statistical results validate the feasibility of using Kinect to objectively assess the medical state in PD patients. Future work includes completing the study with additional patients to achieve significance for other variables, extending to use additional individual information, using insights from the statistical analysis to inform feature selection for machine learning approaches and extending to use data obtained from wearable sensors to ultimately provide fine grained automated mobility assessment methods.

Poster F41: Rehabilitation-Based Motor Pattern Differences after Biological and Bionic Therapies in Spinal Cord Injury (SCI)

Motor Rehabilitation

David Logan[1], John K. Lee[1,2], Qi Yang[1], Simon F. Giszter[1,2]

[1]Neurobiology & Anatomy, Drexel University College of Medicine, Philadelphia,PA, USA, [2]Biomedical Engineering, Drexel University, Philadelphia, PA, USA

The goal of this work was to investigate the underlying organization of muscle activations for locomotion during complete SCI (cSCI) rehabilitation. The clinical utility of multi-modal rehabilitation approaches is a growing area of investigation. For example, epidural stimulation (ES) used in combination with rehabilitation training has recently driven improved motor function in patients recovering from severe SCI. Here, we investigate the combined therapies of robot rehabilitation and Adeno-associated viral delivery of Brain-derived neurotrophic factor (AAV5-BDNF) for locomotive rehabilitation following cSCI in a rat model, followed by addition of robot-driven epidural stimulation. We use information-based techniques (i.e., Independent Component Analysis or ICA) to decompose multi-site muscle recordings to examine dimensionality, identify underlying motor modules, and monitor module structure throughout rehabilitation. SD rats (n=3) were implanted with nine intramuscular EMGs in the right hindlimb, from which baseline EMG recordings were made prior to complete transection (T10) and implantation with stimulating electrodes placed on the spinal cord surface (L2 and S2). All rats received AAV5-BDNF microinjections caudal to injury into the ventral horn of the cord, eliciting spontaneous reflex stepping. After recovery, animals were treadmill trained with robotic pelvic rehabilitation therapy (20 min/session) for three weeks, followed by a second phase of robot-driven (as needed) ES for another three weeks. Throughout training, 2 minutes of perineal stimulation was used to elicit strong stepping every other training session. ICA was used to decompose these EMG recordings into informationally distinct underlying motor modules, and to examine the specific contributions of muscles to each of the modules. Weight matrices were compared among sessions across the training period using correlation. These weight matrix correlations revealed distinct groupings across time. First, there were higher correlations in the weeks before epidural stimulation. Spinalized rats initially showed weak local correlations between weight matrices, and intact rat modules, which then strengthened over this period. ES applied subsequently altered these correlations, suggesting a transition in control and modularity occurred between the two rehabilitation phases. The modules no longer correlated as well with intact rats, even after achieving internal stability with a return to high correlations among days achieved in the final two weeks. The modules after ES training correlated less well with the intact rat modules compared to the AAV5-BDNF rehab phase. In sum, contributions of muscle activity to these decompositions appear to be different between the No ES and ES phases of the rehabilitation. These data suggest that early spontaneous locomotive recovery aided by AAV5-BDNF elicits contributions of muscle activations to locomotive recovery that more closely resemble pre-transection patterns than do those observed during ES. Furthermore, dimensionality and muscle contributions alter throughout rehabilitation but different modalities of therapy appear not to elicit the same spinal muscular groupings / activations during recovery.

Support for this research provided by the Brody Family Medical Trust Fund Fellowship in "Incurable diseases" of The Philadelphia Foundation.

Poster F42: Associations Between Foot Cutaneous Sensation and Muscle Activation Patterns During Unexpected Lateral Perturbations After Stroke
Stroke

Vicki Gray, Chieh-ling Yang, Sandy McCombe Waller, Mark Rogers
University of Maryland, Baltimore, USA

A protective step is commonly used as a strategy to recover and stabilize the body when one's balance is disturbed. After a stroke, balance recovery is difficult with many falls occurring as weight is transferred laterally. Foot plantar sensation may normally be an important sensory input contributing to the sensorimotor control of protective stepping that can be disrupted following stroke. The purpose of this study was to determine the associations between foot plantar cutaneous sensation and muscle activation patterns during protective stepping in response to an unexpected lateral waist-pull to the paretic and non-paretic side in persons with chronic stroke.

Fourteen community dwelling individuals who were > 6 months post-stroke participated in the study. Participants were fitted into a safety harness and were tested using a lateral waist-pull system to induce steps. There were 18 randomly ordered trials and participants were instructed to react naturally and prevent themselves from falling. The electromyographic (EMG) activity was recorded bilaterally from the adductor magnus (AD), gluteus medius (GM), rectus femoris (RF), biceps femoris (BF), tibialis anterior (TA), and soleus (SOL) muscles with surface electrodes during 18 lateral waist-pull trials. Cutaneous sensation was assessed on the plantar aspect of the foot with monofilaments. Correlation coefficients (r) were calculated to determine the strength of associations between the EMG onset and magnitude and cutaneous sensation.

The first recovery step was initiated by the non-paretic leg 63. 4% of the time and 36.6% by the paretic leg. For non-paretic leg stepping, greater impairments in cutaneous sensation of the paretic foot were correlated with an increased EMG area of the GM ($r=0.27$; $p=0.003$), RF ($r=0.40$; $p<0.001$) and TA ($r=0.26$; $p=0.003$) muscles. The EMG area was increased by 27.7% in the GM, 61.4% in the RF and 51.5% in the TA muscles during the first recovery step. For the paretic limb steps, greater impairments in cutaneous sensation were correlated with the initiation time of the AD ($r=0.28$; $p=0.05$), GM ($r=0.40$; $p=0.002$) and TA ($r=0.34$; $p=0.01$) muscles. However, significant differences from the non-paretic limb in the initiation time were only found in the paretic AD ($p=0.002$) and GM ($p=.008$) muscles, with a delay of 130 and 110 ms.

The results indicated that persons with more severe sensory impairments of the paretic foot compensate with increased muscle activity when recovering balance with the non-paretic limb. They also, have a delayed onset of muscle activity in the paretic hip muscles when the first step used to recover balance was the paretic leg. This demonstrates the importance of plantarflexor cutaneous sensation and the role it plays in the ability to recover balance from an expected perturbation after a stroke.

Grant Support: AHA 14CRP19880025; NIDRR H133F140027; NIDRR H133P100014

Poster F43: Towards a Low-Cost Alternative for BCI-aided Neurorehabilitation: A Comparison of the Emotiv Epoc to a Clinical EEG System

Motor Rehabilitation

Camilo Aguilar[1,2], Omar Shanta[1], Thuong Tran[1], David Reinkensmeyer[1], Sumner Norman[1]

[1]University of California, Irvine, Irvine, California, USA, [2]Purdue University, West Lafayette, Indiana, USA

Brain-computer interfacing (BCI) is a form of human-machine interaction with potential to enhance rehabilitation therapy after neurological injuries. The most common method used to capture data in BCI is electroencephalography (EEG). In EEG, electrodes embedded in a non-invasive cap detect electrical signals over the user's scalp. The BCI then decodes these signals to control an external device, such as a wheelchair or exoskeleton robot.

Although EEG has proven useful for neurorehabilitation, typical systems are very expensive, limiting their use to clinical and research settings. In recent years, low-cost alternatives, such as the Epoc by Emotiv©, have targeted widespread use of BCI including bringing BCI into the home.

In this study, we compared the low-cost Epoc headset to a more expensive clinical grade EEG system: the EGI Clinical Geodesic hydrocel. The Epoc consists of 14 dry electrodes and samples at 128 Hz, while the EGI uses 256 electrodes and samples at 1000 Hz. We collected data from six (N=6) unimpaired subjects (4 right-handed, 5 Female) using their left hand to play a musical computer game, similar to Guitar Hero©. Participants received robotic assistance from the Finger Individuated Grasping Exercise Robot (FINGER). We used a two factor, two level factorial design where the factors were robot assistance (on or off) and overt motor activity by the subject (active or passive) resulting in 4 experimental conditions. Participants completed a total of 62 trials in each condition.

We investigated the ability of each EEG system to reliably detect Event Related Desynchronization (ERD), a commonly used signal for BCI-contingent robot therapy. ERD refers to the reduction in amplitude of mu (8-13 Hz) oscillations over the sensorimotor cortex, known to precede both overt and imagined movement. The more expensive EGI headset detected significant ERD in all subjects and all movement conditions when compared to passive recording (t-test, $p < 0.01$). The less expensive Epoc detected ERD for only one subject when the participant was active (within-subject MANOVA, $p = 0.0383$). The magnitude of ERD was also significantly greater with the EGI headset (t-test, active subject, $p < 0.01$).

The importance of the sensorimotor cortex in neurorehabilitation means that any EEG system used for BCI must reliably detect motor signals such as ERD. The 14 channels of the Epoc do not adequately cover the scalp, most closely approaching sensorimotor cortex with electrodes at F3/F4 and FC5/FC6. It is likely that the Epoc detected ERD in these nearby channels in one subject through volume conduction, as evidenced by the reduction in ERD magnitude. Although the Epoc shows promise in its ability to detect raw EEG, its electrode placement meant it was unable to reliably detect ERD, thus limiting its potential for applications in robotically assisted therapy.

Poster F44: Employing Patient's Individual Characteristics to Derive Personalized Brain Stimulation Therapies

Stroke

Vishwanath Sankarasubramanian[1], Nicole Varnerin[1], David Cunningham[1], Kelsey Potter-Baker[1], Ken Sakaie[1], Adriana Conforto[2], Andre Machado[1], Ela Plow[1]

[1]Cleveland Clinic, Cleveland/Ohio, USA, [2]Sao Paulo University, Sao Paulo, Brazil

Background: Non-invasive brain stimulation is one of the most well studied advances in stroke rehabilitation. The classical approach focuses on facilitating adaptive plasticity of the damaged hemisphere, particularly the primary motor cortex (M1). However, the promise of stimulation becomes inconsistent when studies include patients with serious damage and disability. In such cases, pathways from M1 are damaged frequently. And, instead, plasticity of alternate substrates in both damaged and intact hemispheres can contribute to recovery. But, how does one identify which substrate to stimulate to precisely affect recovery?

Objective: Since individual substrates offering plasticity vary with damage and disability, we premise outcomes of stimulating these substrates will similarly vary across the range of damage and disability. Comparing their variances will help derive patient-specific substrates for most consistent brain stimulation therapies.

Methods: In a repeated measures crossover design, patients with chronic stroke ranging from mild to severe upper limb impairment received stimulation to facilitate damaged M1 and other damaged and intact substrates, besides sham. Patient characteristics including baseline disability and damage were quantified using scores of impairment and corticospinal integrity. Outcomes were indexed as change in functional reaching ability, and individual expressions of plasticity measured using transcranial magnetic stimulation.

Results: Stimulation rather than sham modulated plasticity and outcomes of paretic upper limb. As predicted, outcomes and plasticity of stimulating different substrates varied differently with baseline impairment and damage. While outcomes of stimulating damaged M1 were robust in patients with mild impairment ($r=0.64$), the more seriously impaired best responded to stimulation of intact motor cortices ($r= -0.812$) with cut-offs at mild-to-moderate damage and disability.

Significance: Our findings are consistent with the hypothesis that outcomes of stimulating different substrates vary differently with individual characteristics. The diametrically opposite relationships witnessed between outcomes of stimulating M1 and other substrates could help identify intersection or cut-offs along the range of damage and disability. Cut-offs can stratify patients in which range will benefit from stimulating damaged M1 vs. other substrates for precisely maximizing rehabilitative recovery.

Poster F45: Compensatory Stepping in People with Multiple Sclerosis
MS

Daniel Peterson[1,2], Jessie Huisinga[3], Fay Horak[1,2]
[1]Veterans Affairs Portland Health Care System, Portland, OR, USA, [2]Oregon Health & Science University, Portland, OR, USA, [3]University of Kansas Medical Center, Kansas City, KS, USA

Objective: To characterize compensatory stepping in people with multiple sclerosis (MS) in order to identify possible targets for stepping rehabilitation. Methods: 54 people with MS and 21 age-matched healthy adults underwent forward and backward support surface translations. Slow- "in-place" perturbations (4cm in amplitude, 15cm/s in velocity) and faster- "stepping-response" perturbations (15cm in amplitude, 56cm/s in velocity) were carried out. Body kinematics and shank electromyography were captured. Persons with MS also completed clinical outcomes including the European Database for Multiple Sclerosis Disability Score (EDMUS-DSS) and 25ft timed walk. Results: People with MS exhibited more center of mass movement after perturbations and more pronounced deficits in compensatory stepping characteristics than healthy adults (e.g. step latency, number of steps, anticipatory postural responses). Stepping deficits in MS were observed primarily during backward stepping and were correlated to clinical outcomes (EDMUS-DSS; 25ft walk time). Both healthy subjects and persons with MS exhibited slower muscle onset time after fast translations compared to slow translations. Conclusions: Compensatory steps are altered in people with MS, however these deficits are more pronounced during backward stepping than forward stepping which suggests backward stepping may be more effective at identifying stepping dysfunction in MS. Step latency and anticipatory postural responses are particularly altered during backward stepping in people with MS and may be appropriate targets for neurorehabilitation.

Poster F46: Changes in Corticomuscular Coherence Associated with Different Levels of Isometric Hand Force Production Using MEG

Motor Rehabilitation

Guiomar Niso[2], Sylvain Baillet[2], Elizabeth Bock[2], Patricia da Cunha Belchior[1], Marie-Hélène Boudrias[1]
[1]School of Physical & Occupational Therapy, McGill University, Montreal, Quebec, Canada, [2]McConnell Brain Imaging Centre, Montreal Neurological Institute, Montreal, Quebec, Canada

Introduction

Previous research has shown that 15-30 Hz oscillatory activity in the primary motor cortex (M1) is coherent or phase locked to activity in contralateral hand muscles. This phenomenon has mainly been studied during the production of precision grip task using the index and thumb [1]. In this study, we investigate task-dependent modulation in the coherence between M1 and hand muscles during the production of different levels of grip force, as well as extend this investigation to additional motor areas such as the supplementary motor area (SMA), premotor dorsal (PMd) and premotor ventral (PMv) areas.

Material & Methods

Two healthy female subjects (26 & 41 years old) were scanned while performing hand grips following a hold-ramp-hold pattern with their dominant right hand. We particularly focused on the differences during the three parts of the task: low force hold (3s), ramp (3s) and high force hold (3s). Three different levels of low-high difficulty were analyzed: 10-30%, 20-50% and 30-70% of maximal contraction. Subjects received visual feedback of gripper force levels and were instructed to keep them within target boxes throughout each trial. Surface EMGs were recorded from four forearm muscles: First Dorsal Interossei (FDI), Extensor Carpis Ulnaris (ECU), Flexor Carpi Radialis (FCR), Extensor Digitorum Communis (EDC); and MEG recordings were acquired with a 272-channel CTF system at a sampling rate of 2 kHz. Power spectral density (PSD) using Welch method, Time-frequency (TF) analysis using complex Morlet wavelets, and corticomuscular coherence (CMC) were computed for the different levels of force.

Results:

PSD

MEG sources in M1, SMA, PMd and PMv show clear peaks in the alpha and beta frequency ranges for all force levels. EMG signals also exhibit peaks in the alpha and beta range, the beta peak being more prominent at lower force levels.

TF

M1 and SMA exhibit an increase in beta activity during the holding periods (low and high) that decreases during the ramp period. Similar behaviour was observed for the FDI, ECU and EDC muscle signals, as previously reported [1]. The 20-50% condition exhibited the greater modulation with force.

CMC

An increase in CMC was found in the beta range between MEG and EMG signals during the two holding periods. In particular, M1 and EDC, showed the greatest coherence. This effect diminishes when higher forces were produced.

Conclusion

These results argue in favor of CMC being related to specific parameters of isometric grip force in healthy subjects. These observations will be compared to subjects suffering from stroke and/or other pathological aging processes characterized by motor impairments in a larger subject group.

[1] Kilner et al.,The Journal of Neuroscience, December 1, 2000, 20(23):8838-8845

Poster F47: Distribution of Corrective Movements Differ in People Post Stroke During Paretic Arm Reaching

Motor Rehabilitation

Clinton Wutzke[1,3], Shashwati Geed[3], Evan Chan[2], Rachael Harrington[3,4], Michelle Harris-Love[3,5]

[1]Veterans Affairs Medical Center, Washington, District of Columbia, USA, [2]MedStar Health Research Institute, Washington, District of Columbia, USA, [3]MedStar National Rehabilitation Hospital, Washington, District of Columbia, USA, [4]Georgetown University, Washington, District of Columbia, USA, [5]George Mason University, Fairfax, Virginia, USA

Following stroke, individuals with severe movement impairments commonly have difficulty reaching. To optimize rehabilitation paradigms to improve reaching movements of people post stroke, it is crucial to characterize how reaching in this population differs from those with more mild movement impairments. Movement units (reversals in tangential velocity of the hand during a reach) have been previously used to describe reaching in people post stroke, however this measure may not fully capture differences between functional groups.

The purpose of this study was to develop a novel analysis technique to describe forward reaching by utilizing the onset of corrective movements in people post stroke. We hypothesized that the distribution of corrective movements in people with severe movement impairment would differ compared to people with mild arm impairment post stroke.

Upper extremity function was categorized by score on the Upper Extremity Fugl-Meyer [UEFM] (Severe: score <30; Mild: UEFM score >35). Twenty-five people post stroke (14 mild UEFM: 52.3+9.7; 11 severe UEFM: 17.8+8.4) completed a forward reach task with the paretic limb. Participants completed forward reaching movements with the paretic arm in response to a visual 'Go' cue to targets located at 80% of their maximum voluntary reach distance.

Reach duration was normalized to one hundred data points for each trial. Movement units were identified by significant positive peaks in x-y (horizontal plane) tangential velocity of the hand. Peaks were considered significant if the height of a peak exceeded 15% of the maximum peak velocity. This analysis included 131 forward reaches by people with mild movement impairment and 99 forward reaches by participants with severe arm movement impairment. Analysis was conducted using custom Matlab programs with a significance level identified a priori at $p<0.05$.

A two-sample Kolmogorov-Smirnov test was used to compare the cumulative distribution functions (CDFs) of movement units throughout time-normalized reach in people with mild or severe impairment. The null hypothesis that movement units in mildly- and severely-affected stroke patients are similarly distributed during reach was rejected (test statistic 0.201, $p = 0.004$). The results indicate the onsets of corrective movements are unequally distributed in time during reaching in people with mild and severe arm impairment post stroke.

These results suggest that people with severe arm impairment initiate corrective movements at the mid-point of the forward reach, suggesting a greater dependence on visual feedback. Individuals with mild arm impairment had greater occurrence of corrective movements in the final 10% of the time-normalized reach suggesting a more smooth velocity profile with a corrective movement to make contact with the target. Further analyses are necessary to describe corrective movements during a forward reach in people with severe arm impairment.

Poster F48: Clinical Characteristics Changes of Phantom Phenomen After Traumatic Limb Amputation

Sensory Rehabilitation

Widjajalaksmi Kusumaningsih

Department of Rehebilitation Medicine, Faculty Of Medicine, University Of Indonesia, Jakarta, Indonesia, Indonesia

Background:

The clinical characteristics changes of phantom phenomen after traumatic limb amputation are related to clinical score of referred phantom limb sensation (RPLS) and telescoping measurement.

Objectives:

To identify the changing clinical characteristics of phantom phenomen after traumatic limb amputation.

Methods:

Fifty limb ampute subjects were included in the study and were allocated in two independent group. Group using prosthetic and group not using prosthetic.

Result:

Within six months observation there was an increase in telescoping degree followed by referred phantom limb sensation and lower phantom pain intensity that was statistically significant ($p<0,0001$). There was also significant difference between the two group ($p<0,0001$).

Conclusions:

Changed in clinical characteristics of phantom phenomen after traumatic limb amputation are related to clinical score of referred phantom limb sensation and telescoping. This show the consequence of reorganization of neuroplasticity process. This process was hasten by using functional prosthetic.

Keyword:

Neuroplasticity, Phantom limb, Telescoping, Referred Phantom Limb Sensation

Poster F49: Electrophysiological Mechanisms Underlying Visual Feedback in Prism Adaptation
Neural Repair Mechanisms

S.J. MacLean[1], O.E. Krigolson[2], G.A. Eskes[1]
[1]Dalhousie University, Halifax, Nova Scotia, Canada, [2]University of Victoria, Victoria, British Columbia, Canada

Background: Prism adaptation (PA) is a promising rehabilitation tool for visuo-spatial neglect. Not everyone with neglect responds to PA, however, nor do PA after-effects always generalize to functional tasks. Therefore, a better understanding of the underlying neural mechanisms of PA may be useful to decompose the important processes underlying PA and to optimize PA effects for clinical use. We recently showed that two event-related potentials (ERPs) are evoked by feedback during PA in healthy controls: the error-related negativity (ERN) and the P300. ERP research suggests that the ERN reflects a mid-frontal error processing system responsible for immediate behavioural corrections and the P300 comprises a more posterior "context-updating" system signaling revisions to participants' working model of the environment, but their role in PA is unclear. Purpose: To investigate whether these ERP components play a role in producing PA aftereffects. Thus, we evaluated these components during PA in response to different types of visual feedback that are known to modulate strength of after-effects. Method: Healthy young adults wearing prism glasses performed memory-guided reaches towards vertical line targets spanning a touchscreen. There were three between-subject feedback conditions at screen touch: (1) view of both hand and target (i.e., target reappeared at screen touch), (2) view of hand only (i.e., target did not reappear), or (3) view of target only with a second vertical line to mark hand position (i.e., reaching was performed under an occlusion board). We compared ERPs evoked by onset of these different feedback events as well as the size of their respective after-effects. Results: Feedback with view of hand, both with and without explicit target, led to stronger after-effects (mean error = 5.3° and 5°, respectively) compared to target only feedback with hand position marker (mean PVSA error = 1.8°). Parallel to the size of the after-effects, only feedback conditions involving direct view of the hand evoked a P300 component which decreased in amplitude as adaptation proceeded. In contrast, the ERN was seen only when feedback conditions included the target location, even when after-effects were small or minimal. Conclusions: Given that view of hand produced stronger aftereffects, the P300 component may thus serve as a marker of visuo-motor "realignment" processes that are critical to producing strong aftereffects, while the ERN may reflect a neuro-cognitive process related to strategic recalibration. Furthermore, because the P300 amplitude is maximal at parietal-central electrode sites, these data are consistent with imaging studies suggesting involvement of posterior/parietal lobe areas in PA effects. Further study of the role of these components in PA in individuals with neglect is ongoing.

Poster F50: The Control of Grasp Force for Individuals Who Suffered a Stroke and Age-Matched Controls

Stroke

Charlie E. Anderson, Rajiv George, Vicky Pardo, Kumar Rajamani, Diane E. Adamo
Wayne State University, Detroit, MI, USA

Introduction: Stroke survivors have difficulty overcoming deficits associated with grasping ability that may differ for their right and left hand. The purpose of this study was to determine right and left hand differences in control of grasp force for right handed individuals who suffered a stroke and compare findings to age-matched right handed controls.

Methods: Three groups of participants (22 right hemisphere damage, 20 left hemisphere damage, 23 controls) completed clinical assessments and performed hand-grasp tasks using Instrumented Strain Gauges embedded with force sensors. Pre / post stroke hand preference scores were obtained using the self-reported Edinburgh Handedness Inventory (EHI). A right and left hand reference force was based on 20% of the respective right and left maximum grasp force and provided the reference when matching with the same and opposite hand. Visual feedback, represented by a horizontal line on a computer monitor, displayed the 20% reference force. The matching force, performed without visual feedback, indicated whether the participant overshot or undershot the reference force and this value quantified the Constant Error.

Results: Pre and post EHI scores for individuals with right hemisphere damage were 0.89 / 1.00 and 0.85 / 1.00, respectively indicating they continued to use the right hand for most tasks. Pre and post EHI scores for individuals with left hemisphere damage were 0.87 / 1.00 and 0.53 / 1.00, respectively indicating less right hand use post stroke. For grasp force matching, the ANOVA showed a significant three-way interaction for matching hand x condition x group, $F_{(4,132)} = 8.9$, $p < 0.05$) for constant error. Individuals with right hemisphere damage showed left hand matching undershoots for right hand reference forces ($p < 0.05$) and right hand matching overshoots for left hand reference forces ($p < 0.05$). Similar directional differences were found in the control group. However, those individuals with left hemisphere damage showed right and left hand overshoots for opposite hand matching ($p > 0.05$).

Discussion: Shifts in handedness scores and the magnitude of directional differences in force matching performance were dependent on lesion location. The control group performed in a manner similar to individuals with right hemisphere damage. Those with right hemisphere damage also continued to use their right hand to perform everyday tasks post stroke. Less direct damage to the left hemisphere in people with left hemiplegia suggests that participants continue to use well-learned right-handed movement patterns. However, those with left hemisphere damage showed significantly less right hand use and consistently overshot right and left reference forces. From a clinical perspective, stroke survivors may not be aware of how shifts in hand use or changes in the control of grasp force influence their ability to perform everyday tasks. Further investigation is warranted.

We acknowledge support for this study **Blue Cross Blue Shield of Michigan Foundation**

Poster F51: Validation of Reaching Movements Made in a 2D Virtual Environment in Typically Developing Children

Motor Rehabilitation

Maxime Robert[1,2], Krithika Sambasivan[2], Mindy F. Levin[1]

[1]Integrated Program in Neuroscience, McGill University, Montreal, Quebec, Canada, [2]Center for interdisciplinary research in rehabilitation of greater montreal, Montreal, Quebec, Canada, [3]School of Physical and Occupational Therapy, McGill University, Montreal, Quebec, Canada

The ultimate goal of rehabilitation is to improve movement kinematics which can be described at two levels: movement quality and motor performance. Measurement of change in movement quality and performance over time is also a method to identify motor learning. Motor learning is based on different principles which can be manipulated in treatment interventions by a therapist or through the use of interactive computer technology, such as virtual reality. Our aim was to compare the kinematics of movements in a physical environment to a similar virtual environment in typically-developing children. Participants (children; 8-17yrs) completed the Edinburgh Handedness Inventory to identify the dominant arm. They practiced reaching in the virtual environment to become familiar with the task. Then, they performed a series of 3 gestures (frontal, vertical and sagittal arm movements) in two environments: virtual and physical environments for a total of 6 gestures. 3D movement kinematics of the arm and trunk were recorded with 6 wireless electromagnetic sensors (G4, Polhemus, Vermont, 120Hz). Participants completed 15 trials of each gesture in each environment (45 trials per environment, for a total of 90 trials). The virtual environment consisted of an interactive game controlled by arm and hand movements (Jintronix, Montreal) projected on a computer monitor. Movements throughout the arm workspace were recorded with a Microsoft Kinect camera and projected into the game scene. Movements made in the virtual environment were less precise, slower and shorter in comparison to those made in the physical environment. In the virtual environment, participants used less trunk displacement in comparison to the physical environment. There were no significant differences between the two environments with respect to the range of motion of the elbow and the shoulder. Differences between movements made in each environment can be explained by less precise body position tracking in the virtual environment, decreased quality of the visual scene and differences in depth perception cues. The overall similarities of movements made in the two environments suggest that training in 2D game-like virtual reality environments may be feasible for motor rehabilitation of children.

Poster F52: Alterations in Cortical Laterality Among Individuals at Risk for Stroke: A Functional MRI Study in Controls and Patients

Stroke

Daniel Lench, Christopher Austelle, Colleen Hanlon
Medical University of South Carolina, Charleston, USA

Background: It is well-known that the first year after a stroke is a dynamic period for brain recovery. One of the hallmarks of this period is that stroke patients begin to use both the left and right hemisphere motor circuitry to perform a unimanual task (which typically involves a lateralized set of motor structures). Although this pattern may be positive during acute stroke recovery, chronic stroke patients that are unable to restore the typical pattern of lateralized activity often have the worst outcomes. The goal of this study was to test the hypothesis that this bilateral activity is actually present before the stroke in individuals at risk for stroke - and may reflect an early pre-stroke adaptation to their risk factors (high blood pressure, diabetes).
Methods: Functional MRI data and a comprehensive battery of motor assessments were acquired from 22 individuals - a cohort of 11 chronic stroke patients with upper extremity weakness (and 11 participants at-risk for stroke (at least 2 cardiovascular risk factors). During the neuroimaging session, the participants performed a squeezing task with their left and right hands (30 second blocks of left, right, or rest). Percent BOLD signal change was extracted from the caudate, pallidum, precentral gyrus, putamen, SMA and thalamus during the hand pulsing task and rest.
Results: These preliminary data were compared with a previous cohort of individuals that did not have these risk factors. As expected precentral gyrus percent signal change increased when using the contralateral hand in controls. The laterality index in the at-risk participants was lower (less lateralized) than the healthy control, but it was not as low as in the stroke patients. This was particularly true in the cortical areas including the motor and premotor corticies.
Conclusion: These data suggest that there is a high degree of variability in the laterality indicies among individuals that have not had a stroke. It is possible then that some of these premorbid patterns may account for the lack of "relateralization" that is observed many chronic stroke patients.

Poster F53: Avoidance Strategies in Response to Animate and Inanimate Obstacles in Young Healthy Individuals Walking in a Virtual Reality Environment
Motor Rehabilitation

Wagner Souza Silva[1,2], Gayatri Aravind[1], Samir Sangani[3], Anouk Lamontagne[1,2]
[1]McGill University, School of Physical and Occupational Therapy, Montreal, Quebec/QC, Canada, [2]McGill University, Integrated Program in Neuroscience, Montreal, Quebec/QC, Canada, [3]Feil and Oberfeld Research Center, Jewish Rehabilitation Hospital, Laval, Quebec/QC, Canada

Many studies have described obstacle avoidance strategies while walking, either in physical or virtual environments. These studies, however, were limited to the avoidance of inanimate objects (e.g. cylinders) or failed to address the influence of the visual and auditory properties of the obstacle in shaping avoidance strategies. This study aims to describe the extent to which three different types of obstacles (cylinder, visual human-like avatar and visual human-like avatar with footsteps sounds) affect the inherent avoidance strategies in young healthy individuals. Healthy young adults (n=4, 50% male, aged 24.7 ±3.5 years (mean ±1SD)) were tested while walking over ground and viewing a virtual environment (VE) displayed in a helmet mounted display (HMD) unit (nVisor SX60). The VE, controlled in Caren-3 (Motek medical), simulated a large room that included a target located 11m straight ahead. In addition, three identical obstacles were positioned 7m ahead in three locations facing the subject (40° right, 40° left, and straight ahead). As the subjects walked 0.5m, one of the three obstacles approached them by walking/moving towards a theoretical point of collision located 3.5m ahead at the midline. Meanwhile, the two remaining obstacles moved/walked away from the participants. The ability of the subjects to steer toward the target while avoiding the obstacles was characterized using the 3D position and orientation of the head recorded from reflective markers (Vicon) placed on the HMD. Preliminary findings show a trend towards smaller minimal distances in all directions when interacting with human-like avatars (left: 1.25±0.47**;** center: 1.22±0.20; right: 1.31±0.24) as compared to cylinders (left: 1.49±0.26**;** center: 1.29±0.12; right: 1.52±0.17). The addition of footstep sounds to human-like avatars did not modify minimal distance values compared to when no footstep sounds were provided (left: 1.20±0.39**;** center: 1.71±0.14; right: 1.31±0.28). Onset times of avoidance strategies were similar across all conditions. These findings suggest that participants had equivalent movement perception of the obstacles regardless of the condition displayed. They also indicate that smaller clearances in the presence of human-like entities may occur due to an inherent real life perception of the avatars resulting in actions that rely on strategies applied during daily locomotion. Finally, the similarity of results following the addition of footstep sounds to the visual human-like avatar condition suggests that avoidance strategies may primarily rely on visual cues.

Key Words: Navigation; Vision; Walking.

Poster F54: Muscle Fatigability and Subsequent Torque Decline During Isometric and Isokinetic Knee-Extension Generated by Sequential Electrical Stimulation
Motor Rehabilitation

Austin Bergquist[1], Vishvek Babbar[1,2], Saima Ali[2], Milos Popovic[1,2], Kei Masani[1,2]
[1]Toronto Rehabilitation Institute, University Health Network, Toronto, Ontario, Canada, [2]Institute of Biomaterials and Biomedical Engineering, University of Toronto, Toronto, Ontario, Canada

Background: Functional electrical stimulation is used in rehabilitation to generate muscle contractions and is conventionally applied using a single active electrode (Single-Electrode-Stimulation; SES). During SES, muscle fibres are activated in synchrony with each stimulation pulse, resulting in the need of unnaturally high stimulation frequencies to generate functional contractions. High stimulation frequencies result in high muscle fatigability and rates of torque decline, negatively impacting benefits of rehabilitation involving electrically stimulated muscle contractions. To address this issue, researchers have "spatially distributed" and "sequentially" interleaved stimulation pulses between multiple active electrodes (Spatially-Distributed-Sequential-Stimulation; SDSS). SDSS allows muscle fibres to be activated in an asynchronous manner, reducing the stimulation frequency at each active electrode, while maintaining activation of the muscle as a whole. Although SDSS has been shown to reduce fatigability and subsequent torque decline of isometric contractions, this method has not been tested under non-isometric conditions, as occurs routinely in rehabilitation.

Purpose: To reproduce previous findings that SDSS can reduce fatigability and subsequent torque decline of isometric contractions, and to extend this line of inquiry to isokinetic conditions.

Methods: Ten healthy volunteers participated in 2, 2-hr, experimental sessions. Intermittent stimulation (0.3-s on : 0.7-s off; 120-s total) was delivered to the knee-extensors using SES (1 active electrode; 40 Hz) and SDSS (4 active electrodes, each stimulated at 10 Hz; composite 40 Hz stimulation) in separate trials, to generate isometric (0°/s) and isokinetic (180°/s) torque. Isometric and isokinetic contractions were tested on separate legs in separate trials. A rest period of 72-hr was provided between repeated testing of each leg. Protocol order was randomized. Stimulation intensity was set to generate ~80% of maximum tolerated stimulation current. Measures of fatigability included fatigue index (average peak torque of last 10 contractions ÷ average peak torque of initial 10 contractions) and torque peak mean (average peak torque of all 120 contractions ÷ average peak torque of initial 10 contractions). Data are reported as mean ± standard deviation and were tested using paired t-tests. Significance was set at $P<0.05$.

Results: Fatigue indices were significantly higher for SDSS than SES during isometric (SES = 0.63±0.09; SDSS = 0.79±0.15; P = 0.002) and isokinetic (SES = 0.67±0.14; SDSS = 0.80±0.18; P = 0.001) contractions. Torque peak mean values were significantly higher for SDSS than SES during isometric (SES = 0.79 ± 0.05; SDSS = 0.89 ± 0.08 $P < 0.001$) and isokinetic (SES = 0.81 ± 0.11; SDSS = 0.87 ± 0.14) contractions.

Conclusion: Presently, we have reproduced previous findings that SDSS reduces fatigability of isometric contractions compared to similar sized contractions generated by SES. Further, we have extended these findings to isokinetic conditions. The present findings are important for understanding the utility of SDSS for use in rehabilitation.

Poster F55: Subcortical Influences on Paired-pulse TMS-induced I-waves in Humans
SCI

John Cirillo[1,2], Monica Perez[2,3]
[1]University of Auckland, Auckland, New Zealand, [2]University of Pittsburgh, Pittsburgh, PA, USA, [3]University of Miami, Miami, FL, USA

Paired-pulse transcranial magnetic stimulation (TMS) of the human motor cortex results in consecutive facilitatory motor evoked potential (MEP) peaks in surface electromyography, allowing the possibility to make non-invasive inferences about the physiology of indirect (I) waves. Using paired-pulse TMS over the hand motor cortex of intact humans and individuals with incomplete cervical spinal cord injury (SCI), we examined early (first) and late (second and third) MEP peaks in a resting finger muscle. In uninjured subjects, we demonstrate a reduced amplitude and duration of the third peak compared with the second, irrespective of test (S1) intensity. A higher conditioning (S2) intensity increased the amplitude of the third but not second peak. No difference in amplitude and duration was found between the first and second peaks. A threshold electrical S2 over the cervicomedullary junction facilitated the second and third but not the first peak similarly to TMS. In SCI subjects, we found a decreased amplitude for all MEP peaks compared with controls. The onset of the second and third peaks were delayed, with the third peak also showing an increased duration. The delay of the third peak was smaller than in controls at a lower stimulation intensity, suggesting lesser influence of decreased corticospinal inputs. A mathematical model showed that the third peak aberrantly contributed to spinal motoneurone recruitment after SCI, irrespective of motor unit threshold. Additionally, temporal and spatial aspects of late peaks in SCI subjects correlated with MEP size and hand motor output. Our results indicate that TMS-induced MEP peaks undergo distinct modulation after SCI, with the third peak likely reflecting a decreased ability to summate descending volleys at the spinal level. We argue that subcortical pathways contribute to late TMS-induced peaks in humans with and without SCI.

Poster F56: Memantine Treatment for Post-stroke Aphasia: A Case Control Study
Cognitive/Language Rehabilitation

Jennie Valles, Juliana Kennedy, Mery Elashvili, Carolin Dohle
Burke Rehabilitation Hospital, White Plains, NY, USA

Objective
To determine if treatment with memantine will improve post-stroke aphasia

Background
Aphasia occurs in 21-38% of stroke victims and is considered one of the more disabling sequelae with significant impact on cognition and communication. Currently, conventional speech and language therapy remains the gold-standard rehabilitation method for improvement of these deficits but studies suggest that adjunctive treatment with pharmacologic agents such as memantine may provide additional benefit.

Design/Methods
A retrospective case control chart review study was conducted examining patients admitted for stroke rehabilitation. Subjects included in our study had received a diagnosis of aphasia based on language assessment by speech language pathology. The treatment group was comprised of 26 patients treated with memantine. These patients were compared to a historical control group matched for age, sex, and stroke severity. Data was collected from medical records over a two-year time period. FIM Cognitive and FIM Motor Scores from admission and discharge were used to calculate the average FIM Cognitive Score Gain and the average FIM Motor Score gain. Changes in the individual FIM Cognitive sub-scores for Comprehension, Expression, Social Interaction, Problem-solving, and Memory were also analyzed. A subgroup of patients had completed portions of the Western Aphasia Battery (WAB). These WAB sub-scores were collected from admission and discharge and evaluated for gains in accuracy. The data were analyzed for normality with the Shapiro-Wilk test. For normally distributed date, an independent sample t-test was used to test for statistical significance between the two groups.

Results
There was no significant difference between the treatment and control groups for FIM Cognitive Score Gain and FIM Motor Score Gain (5.31 ± 4.32 vs. 4.42 ± 3.50 and 16 ± 13.94 vs. 15.96 ± 11.06, $p = 0.991$). Further analysis of the individual FIM Cognitive subscores did not yield a significant difference. The WAB subscores showed no significance in gains in accuracy between the two groups ($15.97\% \pm 13.99$ vs. $19.05\% \pm 13\%$, $p = 0.659$). The scores were also controlled for length of stay. Memantine was generally well-tolerated by both groups.

Conclusion
Memantine treatment showed no statistically significant improvement for patients with post-stroke aphasia based on FIM Scores for Motor and Cognition and components of the WAB. Long-term follow-up and larger study groups, however, could provide additional information which may warrant further exploration into the benefits of memantine. A limitation of our study is the small sample size, highlighting the need for collaboration across multiple research sites in order to allow for collection of data from more patients in order to be adequately powered. Such a system would be of great clinical importance for answering simple, but important research questions that can inform the way we provide rehabilitation.