2016 ASNR Annual Meeting Abstracts

O1: Learned-Subordinant Use of the Paretic Forelimb after Motor Cortical Infarcts in Rats: Effects of Prior Task Experience

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The impact of stroke on the performance of unimanual tasks with the paretic side has been extensively studied in animal models and clinical populations. Its impact on bimanual coordination has not received as prominent attention, though both hands are normally used together for most manual tasks. We recently developed a bimanual skill task, the popcorn retrieval task, which rats perform using coordinated asymmetrical reach and grasp movements with both forelimbs (Dutcher et al., 2013). In rats that are skilled in unimanual reaching, *de novo* training on the popcorn retrieval task after unilateral motor cortical infarcts results in a progressive shift from dominant use of the paretic (uni-manually trained pre-infarct) to the nonparetic forelimb over weeks of training. That is, the task revealed practice-dependent learned subordinant-use of the paretic limb. The present study aimed to characterize (1) how intact animals learn the popcorn retrieval task and (2) how, once established, the bimanual reaching skill is affected by unilateral infarcts of the caudal forelimb area (CFA) of motor cortex. After a shaping period, rats were trained for 20 days (1 session/day) on the popcorn retrieval task, followed by ischemic (endothelin-1 induced) CFA lesions contralateral to the dominant-for-task limb and 20 additional days of testing on the same task. Limb dominance was defined by asymmetries in the number of reach attempts and reach initiations made by each limb. Before the lesions, limb asymmetries progressively increased over the first 11 days of training and then plateaued, suggesting the establishment of a stable inter-limb coordination strategy. This was followed by peak performance (12-14 days), as measured by successful retrievals. After the lesions, the proportions of reaching movements made with either limb converged over the first 2 days, with approximately symmetrical proportions thereafter. There were reductions in reach initiations with the paretic (previously dominant limb), but this limb continued to initiate most reaches. These effects contrast with the complete reversal of limb dominance that was observed with *de novo* post-lesion training on the task. Thus, the pattern of change in bimanual coordination strategies after CFA infarcts varies between a newly learned versus well-established skill.

O2: Cervical Electrical Stimulation for SCI and ALS

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Objective: We have developed a novel method of non-invasive cervical electrical stimulation (CES) to stimulate nerve roots on both sides of the lower cervical cord. We aim to use CES to strengthen residual cervical motor synapses in the context of SCI and ALS.

Methods: Individuals with incomplete cervical SCI, ALS, and able-bodied volunteers participate in this ongoing pilot study. Surface electrodes are placed over the ~C4-C5 levels anteriorly and ~T1-T3 levels posteriorly. A baseline session evaluates CES safety, compares different CES waveforms and polarities, measures post-activation depression response to repeat stimulation, and tests acute interactions between CES and transcranial magnetic stimulation (TMS). Subsequent sessions test different combinations of repetitive stimulation modalities including TMS, median nerve electrical stimulation, and CES.

Results: To date, 10 subjects have undergone >60 CES sessions without major safety or tolerability issues. CES induces action potentials across multiple muscles in both arms in a proximal to distal gradient. At peri-threshold intensity, CES activates motor neurons trans-synaptically via sensory afferents, as observed by a longer latency to hand muscle activation and greater post-activation depression to repeat stimulation at 40 ms. At higher intensity, CES directly activates motor efferents in some but not all subjects. Preliminary analysis of paired TMS and CES has been completed from three able-bodied subjects, two SCI subjects, and two ALS subjects to date. In able-bodied subjects, when TMS is repetitively delivered (at 0.1 Hz) such that it arrives at cervical motor synapses 1.5 ms prior to CES, motor evoked potentials to the APB muscle are enhanced to 195% of baseline immediately after stimulation, 123% at 15 minutes, and 128% at 30 minutes post stimulation. The corresponding results from the two SCI subjects were 118%, 88%, and 93%, respectively. When TMS is repetitively delivered such that it arrives at cervical motor synapses 10 ms after CES, motor evoked potentials to the APB muscle were enhanced to 405%, 91%, and 212% of baseline in the three able-bodied subects, and 164%, 123%, and 246% in the two SCI subjects. Results in two ALS subjects were extremely variable, and two other ALS subjects failed screening due to unobtainable motor evoked potentials. Expanded electrophysiological as well as clinical tests will be presented.

Conclusions: Cervical electrical stimulation is non-invasive, activates multiple upper extremity muscles on both sides simultaneously, and has the ability to target novel interaction sites for convergent peripheral and corticospinal input onto cervical motor neurons. Preliminary results suggest that CES may facilitate corticospinal transmission through a combination of spike timing-dependent plasticity and heterosynaptic summation, although less strongly in subjects with low cervical SCI. Optimizing CES parameters may offer the potential to strengthen cortical control over arm and hand muscles.

O3: Successful Self-Monitoring of Speech Errors Depends on Frontal White Matter Tracts

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Objective: To uncover the neural structures necessary for successful error detection and correction.

Background: The role of error detection and correction in aphasia recovery is poorly understood, although the utilization of error detection and correction has important implications for language therapy (Schwartz et al., 2016). Both production and comprehension therapeutic outcomes correlate positively with patients' ability to detect errors in their own speech (Marshall et al., 1994), yet little is known about error detection itself. Some argue that people detect errors by hearing their own speech, then realizing that what they said misfits what they intended to say (Levelt, 1983). Others argue that error detection occurs in parallel with speech production, and that detection is the result of conflict between several activated responses (Nozari et al., 2011). While the former hypothesis predicts that damage to areas associated with comprehension (i.e. temporal lobe) should correlate with poor error detection, the latter hypothesis predicts that error detection will be associated with damage to frontal brain structures that monitor conflict. The present study tests these hypotheses.

Methods and Results: Using multivariate lesion symptom mapping, we investigated the neural structures necessary for successful error detection and correction in a sample of 37 people with chronic aphasia following left hemisphere stroke. We found that unsuccessful error detection and correction correlate with damage to frontal white matter tracts. Additionally, an inability to correct errors immediately was associated with damage to the superior temporal gyrus (STG) and angular gyrus. To identify which specific tracts are associated with self-monitoring, we then carried out a diffusion tensor imaging (DTI) analysis with the same 37 participants. Controlling for lesion volume, we identified several left and right hemispheric tracts where fractional anisotropy (FA) positively correlated with successful error detection. These include tracts that connect left supplementary motor areas (lSMA) to motor cortex, left and right superior frontal areas, and right posterior middle temporal gyrus (rpMTG) to motor cortex.

Conclusion: Our finding that the integrity of white matter tracts in both the left and right hemisphere predicts error detection performance suggests a domain-general, rather than language-specific, monitoring mechanism. This hypothesis is supported by ERP (Yeung et al., 2004; Riès et al., 2011; but see Acheson & Hagoort, 2014) and fMRI (Gauvin et al., 2016) studies, but we are the first to show a relationship between error monitoring and white matter integrity. Together, these results indicate that a network of frontal white matter tracts is indispensable to the proper self-monitoring of speech. Put within the context of theories on self-monitoring, the results suggest that error detection relies on the interface between regions associated with domain-general conflict monitoring and speech production.

O4: Creating Flexible Motor Memories in Human Walking

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Savings, or faster relearning after initial learning, is a phenomenon observed across many motor learning paradigms including split-belt treadmill walking. When split-belt treadmill walking is used in rehabilitation, the belt speeds are often changed from day-to-day to provide progressive training. However, it is not known if learning is "saved" from one belt speed combination to another. Alternatively, patients may have to learn from scratch in response to each new perturbation. Here we investigated factors in initial learning that facilitate greater savings across different walking speeds.

We collected kinematic data from young adults (n=48) while they walked on a split-belt treadmill. All participants adapted to a split-belt perturbation where the belts moved at different speeds (Adaptation 1), de-adapted with the belts speeds tied, and adapted again to a second split-belt perturbation (Adaptation 2). We tested several groups where the split-belt speeds were systematically changed during Adaptation 1, but were always the same during Adaptation 2 (1.5 and 1.0 m/s, a 1.5 to 1 ratio). Different groups were tested in which we manipulated belt speed parameters during Adaptation 1 (e.g. belt speed difference, average, ratio) to test their effects on relearning in Adaptation 2.

We were surprised to find very low levels of savings when people learned from an identical 1.5 to 1 speed ratio in both Adaptations 1 and 2. Savings was much stronger when people learned a 2 to 1 ratio in Adaptation 1 prior to a 1.5 to 1 ratio in Adaptation 2. Importantly, this was the case even if the actual belt speeds were markedly different in Adaptation 1- savings occurred in groups first exposed to 1.0 and 0.5 m/s speeds or 2.0 and 1.0 m/s speeds (both 2 to 1 ratios). Thus, the ratio of the belt speeds in Adaptation 1 seems to be critical for savings in Adaptation 2, regardless of the actual training speeds. If the ratio is too small, savings does not occur even when the identical perturbation is repeated. No other factors manipulated in Adaptation 1 (e.g. belt speed difference or average) predicted this effect in Adaptation 2.

These findings show that adaptive learning can be stored, recalled, and used to improve performance in different conditions. Our results suggest that experiencing a larger perturbation size (ratio of belt speeds) during initial learning is the necessary ingredient to elicit savings and its transfer to new walking speeds. These findings may be useful when considering how to structure and progress locomotor learning in rehabilitation interventions.

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O5: Cognitively Challenging Exercise to Induce Neural Plasticity in Parkinson's Disease

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Freezing of gait (FoG), the intermittent failure to initiate or maintain walking for people with Parkinson's disease (PD) is a major cause of mobility disability in PD, leading to falls and mortality. While previous data suggest that communication between midbrain locomotor centers (e.g. the pedunculopontine nucleus – PPN) and the frontal cortices (e.g. the supplementary motor area – SMA) within the brain's right hemisphere are partly responsible for FoG, it has not been possible to test novel, effective rehabilitation due to the lack of valid outcome measures for FoG or clearly defined changes in brain physiology associated with FoG. Thus, the current study aims to 1) determine the efficacy of our cognitively challenging Agility Boot Camp (ABC-C) rehabilitation intervention, and 2) evaluate neural mechanisms and plasticity within functional brain networks underlying improvements in mobility and FoG.
Participants were randomized into either our ABC-C physical therapy intervention group or an educational control group for 6-weeks prior to crossing over into the other arm of the study. To date, 13 participants with PD, all with FoG, underwent resting-state functional connectivity Magnetic Resonance Imaging (fcMRI) as well as instrumented measures of gait, balance and FoG severity (with inertial sensors). A blinded examiner conducted objective mobility assessments, along with fcMRI before and after the 6-week rehabilitation protocol.
Six weeks of ABC-C rehabilitation resulted in a significant reduction in fcMRI between the right hemisphere's mesencephalic locomotor region (PPN) and the supplementary motor area (fcMRI reductions ranged from 2-49%), revealing a functional neural locomotor network similar to healthy, age-matched control participants. Participants also showed trends toward better mobility as evidenced by improved performance during the 360^{o} turn test (notorious for evoking FoG) and reduced postural sway during quiescent stance with eyes open and standing on either firm ground or a foam surface. Finally, following the ABC-C intervention reductions in fcMRI of the PPN-SMA locomotor network were significantly associated with improved postural sway while standing on foam ($r = -0.65$; $P = 0.02$).
Following our cognitively challenging 6-week ABC-C rehabilitation intervention, participants with PD showed demonstrable mobility improvements coupled with neural plasticity within brain regions comprising the locomotor network that we have previously shown to have abnormal functional communication in those with PD who experience FoG.

T1: Structural Changes in Descending Motor Tracts Correlate with Improvements in Motor Impairment in Chronic Stroke Patients Undergoing a Trial of Non-invasive Brain-stimulation and Occupational/Physical Therapy

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Motor impairment after stroke has been related to the structural and functional integrity of corticospinal tracts including multisynaptic motor fibers and tracts such as the cortico-rubral-spinal and the cortico-tegmental-spinal tract. Furthermore, studies have shown that the concurrent use of transcranial direct current stimulation (tDCS) with peripheral sensorimotor activities can improve motor impairment. We examined microstructural effects of concurrent non-invasive bihemispheric stimulation and physical/occupational therapy for 10 days on the structural components of the CST as well as other descending motor tracts which will be referred to here as alternate motor fibers (aMF).

In this pilot study, ten chronic patients with a uni-hemispheric stroke underwent Upper-Extremity Fugl-Meyer assessments (UE-FM) and diffusion tensor imaging (DTI) for determining diffusivity measures such as the fractional anisotropy (FA) before and after treatment in a section of the CST and aMF that spanned between the lower end of the internal capsule (below each patient's lesion) and the upper pons region on the affected and unaffected hemisphere.

The treated group (tDCS+PT/OT) showed significant increases in the proportional UE-FM scores (+21%; SD 10%), while no significant changes were observed in an untreated comparison group. Significant increases in FA (+0.007; SD 0.0065) were found in the ipsilesional aMF in the treated group while no significant changes were found in the contralesional aMF, in either CST, or in any tracts in the untreated group. The FA changes in the ipsilesional aMF significantly correlated with the proportional change in the UE-FM ($r=0.65$; $p<0.05$).

The increase in FA might indicate an increase in motor fiber alignment, myelination, and overall fiber integrity. Crossed and uncrossed fibers from multiple cortical regions might be one reason why the aMF fiber system showed more plastic structural changes that correlate with motor improvements than the CST.

T2: Clinically Relevant Levels of 4-Aminopyridine (4-AP) Strengthen Physiological Responses in Intact Motor Circuits in Rats, Especially after Pyramidal Tract Injury

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This study tests the hypothesis that 4-AP enhances the excitability of intact neural circuits at a dose that produces plasma levels in rats similar to those found in effective human trials. 4-AP blocks potassium channels and this is thought to occur primarily in regions of demyelination. However, 4-AP is also able to improve function in a laboratory model of stroke, which lacks large-scale demyelination. In addition, our published study demonstrated that physiological responses to motor cortex stimulation in the uninjured hemisphere could be lost due to injury of the other hemisphere; the responses are restored after administration of a 4-AP dose higher than the approved clinical dose. Here, we test whether this effect can be attributed to uninjured circuits and observed under clinically tolerable levels of 4-AP by testing the motor responses in uninjured rats and from surviving pathways in rats with cut lesion of left pyramidal tract. In anesthetized rats, stimulating electrodes were placed over motor cortex and the dorsal cervical spinal cord for electrical stimulation and electromyogram electrodes were inserted into biceps muscle to measure responses. From a dose-finding study, we determined that 0.32 mg/kg 4-AP infused into the peritoneal cavity produces average plasma drug levels of 61.5±1.8 ng/ml over the 5 hours after infusion. With this dose of 4-AP, EMG responses to spinal cord stimulation increased 1.3-fold in uninjured rats and 3-fold in rats with pyramidal tract lesion. Motor evoked potential responses to cortical stimulation also increased by 2-fold in uninjured rats and up to 4-fold in the injured. All of these changes were significantly different compared to rats randomized to receive saline only. Hence, clinically relevant levels of 4-AP strongly augment physiology responses in intact circuits in rats, an effect that is more robust after partial injury. This mechanism of action appears to complement the effect on demyelination and increases the possible number of CNS injuries and diseases that might benefit from treatment with 4-AP.

T3: An automated Test of Rat Forelimb Supination Quantifies Motor Function Loss and Recovery after Corticopsinal Injury

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Rodents are the primary animal model of corticospinal injury and repair, yet current behavioral tests do not show the large deficits after injury observed in humans. Forearm supination is critical for hand function and is highly impaired by corticospinal injury in both humans and rats. Current tests of rodent forelimb function do not measure this movement. To determine if quantification of forelimb supination in rats reveals large-scale functional loss and partial recovery after corticospinal injury. We developed a knob supination device that quantifies supination using automated and objective methods. Rats in a reaching box have to grasp and turn a knob in supination in order to receive a food reward. Performance on this task and the single pellet reaching task were measured before and after two manipulations of the pyramidal tract: a cut lesion of one pyramid and inactivation of motor cortex using two different drug doses. A cut lesion of the corticospinal tract produced a large deficit in supination. In contrast, there was no change in pellet retrieval success. Supination function recovered partially over 6 weeks after injury, and a large deficit remained. Motor cortex inactivation produced a dose-dependent loss of knob supination; the effect on pellet reaching was more subtle. The knob supination task reveals in rodents three signature hand function changes observed in humans with corticospinal injury: 1) large-scale loss with injury, 2) partial recovery in the weeks after injury, and 3) loss proportional to degree of dysfunction.

T4: Factors Predictive of the Type of Powered Mobility received by Veterans with Disability

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Background: The goal of this observational study was to determine factors predictive of the type of powered mobility prescribed to veterans with disability.

Methods: A retrospective chart review was conducted for all veterans (n=170) who received powered mobility from a designated power mobility clinic. Logistic regression analysis was used to determined factors predictive of the type of powered mobility provided.

Results: Sixty-four (38%) veterans were provided powered wheelchairs and 106 (62%) were provided powered scooters. Of the variables examined, only primary medical conditions for referral and disability severity (as measured by the 2 minute timed walk test; 2-MWT) were predictive of the types of powered mobility prescribed. Veterans who were able to walk longer distances were more likely to be prescribed powered scooters. Age, gender, race, level of education, marital and employment status, number of chronic medical conditions, and upper and lower limb muscle strength were not significant predictors.

Conclusions: This study suggests that the primary medical conditions for referral and 2-MWT can assist clinicians in the determination of the type of powered mobility to prescribe to veterans with disability.

T5: Whole Body Vibration Therapy with Exercise Enhances Motor Function and Improves Quality of Life in Parkinson's Disease

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Background: Pharmacologic intervention is the current standard of care for Parkinson's Disease (PD), yet medications frequently fail to control some symptoms, including tremor and postural instability, which degrade functional performance and quality of life. Non-pharmacological treatments, including Whole Body Vibration (WBV) and exercise therapy may reduce these symptoms.
Objective: To investigate the influence of combined WBV and exercise therapy on functional performance and quality of life in PD.
Methods: A total of fifteen individuals diagnosed with PD (stages I-IV) were identified via the National Parkinson's Foundation Center and recruited on a voluntary basis. Exclusionary criteria included a history of dementia, heart disease, exercise intolerance, stroke, peripheral neuropathy, open wounds and recent surgical implantation. Participants underwent twelve sessions of combined WBV and exercise therapy over the course of six weeks. The treatment regimen consisted of static and dynamic lower body exercises performed on a vibratory platform. Motor performance, functional outcome, and quality of life were assessed using the GAITRite®System, Unified Parkinson's Disease Rating Scale (UPDRS parts 2-3), Beck Depression Inventory (BDI), Fatigue Symptom Inventory (FSI), and Healthy Days Measure (HRQOL-14). Data was collected in three sessions; at baseline before treatment initiation, one day after completion of the six-week therapy program, and again at 4 days after program completion.
Results: One-way repeated measures ANOVA showed statistically significant improvements in combined UPDRS scores $F(1.474, 20.64) = 26.37$, $p < 0.001$, decreasing from 29.53 ± 7.60 (baseline) to 18.00 ± 7.09 (1 day post-intervention) and 17.53 ± 5.78 (4 days post-intervention). Post-hoc analysis revealed UPDRS score decrease from baseline to 1 day post-intervention (10.13 (95% CI, 4.86,15.41) $p < 0.001$), and from baseline to 4 days post-intervention (10.73 (95% CI, 6.22, 15.25) $p < 0.001$). Significant improvements were also observed in post-interventional examinations for gait velocity, cadence, and double support time. No significant change was observed in FSI, BDI, and HRQOL-14 scores.
Conclusion: Combination WBV-exercise therapy has significant positive short-term influence on motor performance, activities of daily living, and postural stability. Further investigation is needed to determine long-term effects.

T6: The Effect of Unilateral Balance Training on Postural Control of the Contralateral Limb

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AIM: To investigate the impact of unilateral balance training on postural control of the trained and contralateral limb.

METHODS: Fifty-one healthy adults were randomly assigned into training group (TG) and control group (CG). Participants of the TG performed unilateral balance training (dominant (DOM) leg) over 4 weeks (4x/week). Center of pressure analysis was performed at baseline, 5-weeks follow-up (TG and CG) and 9-weeks follow-up (only TG) under the following conditions: (1) one leg stance without additional task, (2) one leg stance with additional motor task and (3) one leg stance with additional cognitive task.

RESULTS: From baseline to 5-weeks follow-up a two-way mixed ANOVA detected a significant time x group interaction for the DOM leg ($p<0.05$), indicating higher improvement of the TG in comparison to CG. No significant interaction effect was found for the non-DOM leg. Within the TG, the non-DOM leg significantly improved in several COP variables from baseline to 5-weeks follow-up ($p<0.05$). Improved performance was retained after 4 weeks without training.

CONCLUSIONS: Unilateral balance training was effective to improve postural control of the trained leg. The effect on the contralateral leg was small and not significant within this study design. Improvements were retained after 4 weeks without training. A tendency is given that unilateral balance training might be beneficial to improve postural control of the contralateral leg.

T7: Proportional Stroke Recovery in the Rat: Evidence For a Cross-Species Biological Recovery Process That Incorporates Initial Impairment, Infarct Volume and Rehabilitation Intensity

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Objective: Initial post-stroke impairment level and corticospinal tract lesion load have been identified as the most important predictors of functional recovery across time for human stroke. The present study sought to identify if similar biomarkers predict recovery of post-stroke function in rats, indicating that an endogenous biological recovery process might be preserved across mammalian species. We then further investigated the roles of initial impairment, infarct volume and rehabilitation on this process. **Methods:** In a retrospective analysis of 593 male Sprague-Dawley rats we predicted post-stroke change in pellet retrieval (PR) in the Montoya staircase task based on the proportional recovery rule: $\Delta PR_{Predicted} = 0.7(PR_{Pre\text{-}stroke} - PR_{Initial})$. Stratification of the sample into "fitters" and "non-fitters" of this rule allowed identification of distinguishing characteristics using linear regression. **Results:** Approximately 30% of subjects were identified as "fitters" of the rule. Less severe infarct volumes and initial post-stroke impairments with a higher intensity of rehabilitation distinguished this group from "non-fitters". Interestingly, by using these characteristics to model recovery across the total sample we demonstrated that recovery could only be reliably predicted when rehabilitation is present. **Interpretation:** These findings suggest that proportional recovery is a cross-species phenomenon that can be modeled in Sprague-Dawley rats. Additionally, as infarct volume and initial impairment grow more severe, more intense rehabilitation is required in order to engage biological recovery processes.

T8: Effects of an Aerobic Exercise Intervention on Aging Related Changes in Interhemispheric Inhibition

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It has long been shown that physical fitness is associated with improved psychomotor speed and motor dexterity (Spirduso, 1975). Recent cross-sectional work comparing physically active older adults with sedentary age cohorts has shown that these behavioral changes may be due to alteration of interhemispheric communication as a result of aerobic exercise. However, it is unknown if a relatively short-term exercise regimen confers similar benefits in aging adults. Therefore, in the present study, we enrolled 16 reportedly sedentary older adults into either a 12-week aerobic exercise (cycling) or a 12-week anaerobic training program (balance). Participants were randomly assigned to either group at study outset and then crossed-over into the alternate program for another 12 weeks. Behavioral and transcranial magnetic stimulation (TMS) assessments were completed at study outset and after completion of each program. Functional MRI involving right hand finger tapping was also performed pre/post intervention. Distal dexterity (coin rotation and pegboard tasks) significantly improved after both training programs. However, the aerobic exercise group showed the largest behavioral improvement coupled with increases in interhemispheric inhibition as assessed by TMS measures of the ipsilateral silent period and paired pulse interhemispheric inhibition. Implications of alteration of neural inhibition based on increased engagement in physical activity will be discussed.

T9: Neural Correlates of Dual-Task Walking: Influence of Priority on Attentional Demands

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Walking while simultaneously performing another task requires divided attention, eg. holding a cup without spilling. Stability control during gait alone requires attention, which may be compromised as the cognitive demand increases. Our primary goal was to investigate neural correlates associated with increased attentional demands when holding a hot coffee/tea cup versus a cup of room-temperature water while 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. 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) by dividing the walking trial in three different time segments, acceleration, steady-state walking and deceleration. In healthy controls, walking while holding a hot beverage was associated with an increased activation of the dorsolateral prefrontal cortex (DLPFC) only during the acceleration and deceleration phase. In addition, the comparison of walking with a liquid medium (water/coffee/tea) vs a semi-liquid medium (jello) resulted in activation of SMA and DLPFC during acceleration and steady-state walking phase. On the other hand, comparison of walking with water vs jello in stroke participant results in cortical activation of lesioned as well as contralesional hemispheres. During acceleration, DLPFC of the lesioned hemisphere showed increased activation while steady-state walking was associated with increased activation of the contralesional DLPFC. The deceleration phase showed bilateral activation of the prefrontal cortex. The results of the study suggest that walking with a hot beverage increases priority on attentional demands which are associated with activation of the prefrontal cortex during different phases of dual-task locomotion.

T13: Acute improvements in lower extremity motor control of chronic stroke survivors following Assisted Cycling Therapy

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Introduction
Stationary Assisted Cycling Therapy (ACT), which is exercise at relatively fast cadences with the help of a motor, has been shown to reduce tremor and improve gait in patients with Parkinson's disease and to improve upper extremity motor control in persons with Down syndrome or Parkinson's disease. We tested the acute effects of ACT on lower extremity motor control in chronic stroke survivors.
Methods
Twenty one chronic stroke survivors (m/f = 16/5; age = 59.6 ± 15.4 (mean ± SD), months since stroke = 98.8 ± 87.2, BMI = 30.8 ± 6.0, Lower Extremity Fugl Meyer = 20.9 ± 7.8) completed three pseudorandomized and counterbalanced cycling sessions on three separate days. During each visit, participants completed the Lower Extremity Motor Coordination Test (LEMOCOT) in a seated position before and immediately after each cycling session. Participants had to alternately tap two targets as fast possible for 20 seconds with their big toe, one leg at a time. ACT sessions consisted of a five minute warm up of voluntary cycling against minimal resistance and 20 minutes of ACT. Voluntary cycling (VC) sessions consisted of 25 minutes of cycling at a self-selected cadence without help from the motor. During no cycling (NC) sessions, the participant would sit on the bicycle for 25 minutes without pedaling. Linear mixed model analyses and paired sample t-tests were used.
Results
The mean ACT cadence and heart rate were 82.6 ± 10.1 rpm and 91.1 ± 17.0 bpm, respectively. The mean cadence and heart rate for the VC condition were 51.6 ± 14.3 rpm and 93.2 ± 19.8 bpm, respectively. The mean heart rate during NC was 74.3 ± 14.9 bpm. There was a significant main effect of intervention on LEMOCOT scores for the non-paretic leg ($F(2,37) = 7.85$, $p = 0.001$). A significant improvement in the non-paretic leg for the ACT (pre: 44.1 ± 11.4, post: 49.7 ± 12.4; $t(20) = 6.73$, $p < 0.001$) and the VC intervention (pre: 44.0 ± 10.9, post: 48.6 ± 10.7; $t(20) = 4.44$, $p < 0.001$) were found. There was no significant main effect of intervention for the paretic leg ($F(2,37) = 0.05$, $p = 0.956$). However, there was a significant improvement in the paretic leg for the ACT intervention (pre: 15.8 ± 16.7, post: 17.5 ± 17.8; $t(20) = 4.03$, $p = 0.001$).
Conclusion
Lower extremity coordination was improved in the paretic and non-paretic leg following ACT. The results indicate that cycling at a fast cadence is more beneficial for lower extremity motor control than cycling at a slower, voluntary cadence. Possible mechanisms for the improvement include enhanced corticospinal excitability and plastic changes such as a change or expansion of the cortical representation of the lower extremities.

T14: The performance and retention of a skilled walking task among people with an incomplete spinal cord injury

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Background: Many people with a motor-incomplete spinal cord injury (m-iSCI) can recover some basic walking ability; however they experience difficulty when performing more skilled walking tasks (e.g. stairs and obstacles). There is potential for task specific locomotor training based on principles of motor learning to improve the motor control of walking in people with m-iSCI. The purpose of this study is to determine how well people with m-iSCI can learn a new skilled walking task, and retain their performance after a week.

Methods: Participants with m-iSCI (American Spinal Cord Injury Assessment; ASIA D) and age-matched controls performed a skilled walking task focused on foot height during the swing phase. They were presented with a virtual target that they were instructed to match during the swing phase along with real-time visual feedback of their foot height for 600 steps. The target height changed for each step based on a percentage of their maximum step height. We conducted a baseline and post-training test of 20 steps without visual feedback. A 20 step retention trial without visual feedback was repeated 24 hours, 48 hours and 1 week later. Following the retention trial at 1 week, participants performed 300 steps with visual feedback to re-learn the task. Foot trajectory error was measured as the vertical distance between the target and actual foot height. We also measured lower limb muscle activity and sagittal joint angles.

Results: SCI and control groups reduced their average foot trajectory error to 16.7 mm and 10.2 mm, respectively, in the last 20 steps of training. Performance was maintained during the post-test without visual feedback at 17.8 mm and 12.8 mm, respectively. However, average performance on retention trials increased to baseline levels for both groups (SCI: 86.2 mm, control: 43.1 mm). During the initial training session, it took SCI participants 39-87 steps and controls 30-53 steps to learn the task (i.e. 5 consecutive steps within 2 standard deviations of the final performance). Participants were able to re-learn the task faster at 1 week when visual feedback was given (SCI: 9-20 steps, control: 16-30 steps).

Conclusions: Preliminary findings indicate that individuals with m-iSCI were able to learn a skilled walking task at a similar level to abled-bodied adults. Although performance is not maintained after 24 hours, people are able to re-learn the task at a faster rate. Further data collection is warranted to understand the capacity and limitations of individuals with m-iSCI to acquire and learn new locomotor skills.

T15: Can arm cycle training affect postural control and voluntary trunk muscle activation in people with spinal cord injury?

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Objectives: For people with spinal cord injury (SCI), regular exercise is crucial for improving functional mobility, as well as reducing the risk of secondary health concerns such as cardiovascular disease and obesity. Seated arm cycling has been shown as an effective form of aerobic exercise for people with SCI, which also offers the potential to engage the trunk muscles. Recent studies have demonstrated motor preservation of trunk musculature below the level of injury for people with complete cervical and high thoracic SCI. Since there is potential to improve trunk muscle activation, it is important to develop interventions to target these muscles. Training trunk muscles may enhance seated balance control which can directly impact independence in activities of daily living and functional mobility. The aim of this study is to evaluate the effect of an 8-week arm cycle class on seated balance control and the voluntary activation of trunk muscles for those living with SCI.

Methods: Modeled after conventional spin classes, individuals with SCI attended a 1 hour arm cycle class every week for 8 weeks. Classes varied in difficulty by changing resistance levels, cycling cadence, and sitting posture (analogous to standing pedaling bouts in conventional spin classes) to challenge the cardiovascular system and encourage core stability. We evaluated seated balance control and voluntary trunk muscle activation patterns pre and post 8 weeks. Seated balance control was assessed by having participants sit on a forceplate while calculating their center of pressure (COP) during quiet unsupported sitting with eyes open (EO) and eyes closed (EC). We also tested the limits of stability (LOS) by asking participants to lean as far as they could in the 8 cardinal directions, and calculating the total distance the COP moved. EMG patterns were recorded from the rectus abdominus, external oblique and erector spinae (trunk flexion and rotation, lateral flexion, hollowing). We also recorded heart rate (HR) during each class to verify the aerobic intensity of the activity.

Results: Individuals with SCI showed limited trunk muscle activation and impaired static (EO and EC) and dynamic (LOS) seated balance control prior to joining the arm cycle class. Following 8 weeks of arm cycling individuals with SCI tended to show improvements in voluntary trunk muscle function and core stability.

Conclusion: Preliminary findings indicate that an 8-week arm cycle class could potentially improve postural control and elicit training effects in trunk musculature. Moreover arm cycle classes may provide aerobic benefits from an increase in HR reducing the risk of secondary health complications commonly found in those with SCI.

T16: Revisiting interhemispheric imbalance in chronic stroke: a tDCS study

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At the chronic stage of stroke patients with moderate-severe upper limb (UL) impairment rely on descending commands from the contralesional motor cortex (M1) for controlling both ULs. Although this may seem maladaptive, recent studies have shown that down-regulation of contralesional M1 excitability produces neurophysiological or behavioral deficits. We examined whether anodal transcranial direct current stimulation (a-tDCS) would increase contralesional M1 excitability and improve paretic UL coordination in a circle drawing task. We also explored associations between behavioural change scores and potential biomarkers derived from clinical, neurophysiological and neuroimaging variables. Patients were clinically assessed on measures of UL impairment, function and spasticity, then received a-tDCS, cathodal (c-tDCS) or sham stimulation in randomised order across separate sessions. The target electrode was positioned over contralesional M1 (1 mA, 20 cm^2, 15 min). Contralateral and ipsilateral corticomotor pathway excitability was examined using transcranial magnetic stimulation and motor evoked potentials (MEP). Fractional anisotropy within the posterior limbs of the internal capsules, and basal gamma-amino butyric acid (GABA) concentration in each M1, were assessed with magnetic resonance imaging (30 diffusion directions, b=2000) and spectroscopy (MEGA-PRESS) respectively at 3T. For the group, chronicity was 113 (14-192) months, impairment on the UL Fugl-Meyer scale was 27 (9-58, max 66), Action Research Arm Test scores were 21 (0-57, max 57) and spasticity on the Modified Ashworth Scale ranged from 1-3. Both contralateral (P = 0.017) and ipsilateral (P = 0.092) MEPs were facilitated after a-tDCS, and accompanied by a trend toward improved circle drawing (aspect ratio, AR) with the paretic UL (P = 0.085). The effect of a-tDCS on AR was associated with chronicity (R = 0.88, P = 0.002) and spasticity (R = 0.70, P = 0.036) such that those with greater chronicity and spasticity achieved the most benefit from contralesional a-tDCS. The effect of c-tDCS on AR was associated with baseline motor performance (R = 0.80, P = 0.01) and GABA:Cr ratio within ipsilesional M1 (R = 0.75, P < 0.013). Contralesional c-tDCS did not suppress corticomotor excitability (P > 0.24) or influence AR (all P > 0.80). These findings indicate that further increasing contralesional excitability may benefit some patients. This study identifies potential biomarkers that may be useful for identifying patients who are suitable for contralesional tDCS.

T17: The contribution of intact hemisphere dorsal premotor cortex to paretic arm motor performance after severe stroke

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Stroke affects almost one million Americans every year and many are left with long-term effects. One such effect is chronic post-stroke arm impairment, which can drastically affect independence in activities of daily living and quality of life. Existing treatments are of limited efficacy, particularly for patients with relatively severe post-stroke arm impairment. We examined how transcranial magnetic stimulation (TMS) perturbation of several sites within the intact hemisphere [dorsal premotor cortex (PMd), primary motor cortex (M1), and dorsolateral prefrontal cortex (DLPFC)] during a reaching task affected reaching performance. Chronic stroke patients who had not recovered active wrist or finger extension in the affected arm, but had partial shoulder/elbow movement, participated in the study (n=15). Patients were instructed to, upon seeing a visual 'Go' signal, reach forward as quickly as possible with the affected arm to contact a target placed at approximately waist height and oriented in the horizontal plane. TMS (double-pulse; ISI 25 ms; 120% of resting motor threshold for unaffected biceps) was delivered over M1, PMd, or DLPFC of the intact (i.e. ipsilateral) hemisphere during the reaction time period between the 'Go' signal and the onset of movement. Analysis of hand-path kinematics in trials with vs. without TMS perturbation revealed that perturbation of PMd resulted in a significantly greater reduction in speed of reaching (movement time) than occurred with perturbation of M1 or DLPFC ($p<0.05$). Analysis of hand path parameters showed that stimulation of PMd, but not M1, resulted in a longer overall trajectory of movement ($p<0.05$), a greater decrease in the smoothness of the movement ($p<0.05$), and a larger increase in endpoint error ($p=0.05$). Taken together, these results suggest that PMd of the intact hemisphere can contribute to the speed and trajectory of affected arm reaching movements in patients with severe arm impairment.

T18: Changes in inter- and intra-limb coordination following locomotor training in people with spinal cord injury

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Background: In individuals with motor-incomplete spinal cord injury (m-iSCI), the ability to functionally ambulate is reduced, partly due to the skilled walking requirements in our everyday lives. The ability to modify gait patterns for skilled walking requires appropriate intra- and inter-limb coordination. Following SCI, coordination within a limb (intra-limb coordination) and the coordination between limbs (inter-limb coordination) can be impaired, which may contribute to the reduced ambulatory capacity among individuals with SCI. The aim of this project was to determine whether intra- and inter-limb coordination can be improved following body weight supported treadmill training with a velocity-dependent resistance applied to the lower limbs and whether improvements in coordination are related to improvements in functional walking capacity.

Methods: Individuals with chronic m-iSCI were randomly assigned to body weight support treadmill training (BWSTT) with Lokomat-applied resistance (Loko-R) or to conventional Lokomat assisted BWSTT (Control). Training sessions lasted 45 minutes, 3 times a week for 3 months. Before (baseline) and after (post-training) training, lower limb joint kinematics were recorded while participants walked on a treadmill with body weight support at their comfortable and fastest speed. Motion capture markers were used to determine, hip, knee and ankle angles during walking. Joint angles were used to determine overall range of motion and intra- and inter-limb coordination. Over-ground skilled waking capacity, measured by the Spinal Cord Injury Functional Ambulation Profile (SCI-FAP), walking speed (10-meter walk test), and endurance (6-minute walk test) were also measured at baseline and post-training.

Results: Following training individuals in the Loko-R group tended to have greater joint range of motion during gait compared to the Control group, and also tended to show improvements in lower limb coordination. The Loko-R group also showed greater improvements in over-ground skilled walking capacity compared to the control group.

Conclusion: Lower limb coordination can be improved by BWSTT with Lokomat-applied resistance. This data suggests that skilled walking capacity, range of motion and lower limb coordination could potentially be used to show improvements in motor control following SCI.

T19: The effect of rehabilitation on the reorganization of corticospinal tract after spinal cord injury in mice

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Spinal cord injury (SCI) is one of the most devastating neurological injuries that elicit motor and sensory dysfunctions. It is known that the motor recovery occurs to some extent after incomplete SCI by rehabilitation. However, the underlying mechanism of the functional recovery with rehabilitation remains a significant question.
To address this issue, we focused on the compensatory neural tracts. This pathway is composed of collaterals sprouted from the damaged corticospinal tract (CST), propriospinal neurons and motor neurons, and can contribute to spontaneous functional recovery by bypassing the lesion. Moreover, these collaterals first sprout randomly and then the excess collaterals are eliminated, a process called axon pruning. The axon pruning is also observed during the neural development and is considered as an important process that leads to the elimination of the unnecessary neural circuit and the strengthening of the necessary one in order to elaborate the neural pathway. Therefore, we hypothesized that rehabilitation improved motor recovery by enhancing the axon pruning.
First, we made incomplete SCI model mice by dorsal hemisection at T8 level, and injected anterograde tracer, biotinylated dextran amine, into hindlimb motor area to label the collaterals from CST. Then, we counted the number of collaterals in sham mice and injured mice with time. As a result, we reconfirmed that pruning of excess collaterals occurs from 10 days to 28 days after injury. Secondly, we divided injured mice into two groups and trained mice in one group by using the rotarod from 14 days to 28 days after injury. Then we compared the number of collaterals and motor recovery between trained and control mice. As a result, we found that the collaterals in trained mice were pruned more than that in control mice at 28 days after injury and trained mice showed better motor performance.
These results suggest that rehabilitation may improve motor recovery by facilitating axon pruning.

T20: The relationship between fatigue and quality of life after stroke

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Background: Fatigue is a common complaint among individuals survived from a stroke. Previous investigations have reported that post-stroke fatigue negatively affects patients' recovery and functional independence. Little is known about the effect of post-stroke fatigue on quality of life. The present study aimed to 1) compare the severity of fatigue between individuals with and without stroke and 2) examine the relationship between post-stroke fatigue and health-related quality of life in patients with stroke.

Methods: One hundred individuals with chronic stroke (> 6 months) (37 females, mean age = 63 years) and one hundred age-matched healthy controls (58 females, mean age = 60 years) participated in this cross-sectional study. Impact and levels of fatigue were measured by the Fatigue Severity Scale (FSS) and Visual Analog Scale-Fatigue (VAS-F). Health-related quality of life was measured using Short-Form Health Survey 36-version 2 (SF-36 v2). In addition, we measured participant's presence of depression with the Patient Health Questionnaire 9 (PHQ-9), cognition with the Mini Mental State Exam (MMSE) and functional independence with the Barthel Index (BI). The two-sample Kolmogorov-Smirnov test was used to compare the fatigue measures between the two groups. The correlation between fatigue and quality of life was analyzed using Spearman correlation coefficient. All alpha levels were set at .05.

Results: The stroke group demonstrated a significantly greater degree of fatigue (FSS = 28.7 ± 10.7 vs. 15.9 ± 9.6; VAS-F = 4.1 ± 1.8 vs. 2.3 ± 1.6, both $p < .01$) than the control group. In addition, 23% of participants with stroke presented pathological fatigue (indicated by FSS > 36) while only 5% of the control participants presented pathological fatigue ($p < .01$). The FSS showed significantly negative correlations with 5 out 8 sections of SF-36 v2 (Role-Physical: r = - 0.22; General Health: r = -0.24; Vitality: r = - 0.28; Role-Emotional: r = - 0.24; Mental Health: r = -0.24). The VAS-F significantly correlated with General Health (r = -0.28), Vitality (r = - 0.22), and Mental Health (r = - 0.20).

Discussion and Conclusion: Although post-stroke fatigue was evident in individuals recovering from stroke, its influence on health-related quality of life was weak. The significantly lower quality of life found in participants with stroke might be better explained by other factors, such as motor impairment, cognitive impairment, or activity limitations.

T21: Changes in corticospinal tract microstructure are associated with motor performance improvement in chronic stroke

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Background: Microstructure of corticospinal tract (CST) characterized by diffusion tensor imaging (DTI) has been shown to be a significant predictor of motor recovery after stroke in both acute and chronic stroke. While CST microstructural change during the early phase has been shown to be associated with motor recovery, there is no study showing a significant relationship between the change in CST microstructure and the change in motor performance in chronic stroke. **Purpose:** This study aims to determine if a change in ipsilesional CST (iCST) fractional anisotropy (FA) is associated with improvement in paretic upper extremity (UE) motor performance over a three-month intervention period. These data are a subset of a longitudinal Phase-I clinical trial of rehabilitation in chronic stroke (ClinicalTrials.gov ID: NCT01749358). **Methods:**Those with mild-to-moderate UE motor impairment participated (N=28, chronicity range = 0.47 to 14.38 years). MRI scans and clinical assessments were acquired at baseline and post a 3-month period. Imaging data were processed using BrainSuite14a (http://brainsuite.org/). CST tractography was reconstructed for both ipsi- and contra-lesional sides, and 3-dimensional CST masks were generated for each side. Average FA values of each voxel within CST mask was calculated for each side, and CST FA asymmetry index (FAAI) was derived. The primary motor outcome was average Wolf Motor Function Test (WMFT) log time score of distal control items. Significant changes in DTI and motor performance variables were assessed using repeated measures ANOVA. Relationship between change in DTI variables and change in motor performance was assessed using linear regression. **Results:**There was a significant decrease in WMFT log time score over a 3-month period (mean ± standard deviation of changes = -8.4±10.8 %, $p < 0.05$). Changes in the iCST FA and FAAI were not significant ($p = 0.82$ and $p = 0.15$, respectively). However, the linear regression revealed that changes in iCST FA and FAAI explained 35 % ($p < 0.0001$) and 33 % ($p < 0.01$) of the variance in change in log time score of WMFT distal items, respectively. **Discussion:** This is the first study in a chronic stroke population that has demonstrated a significant relationship between CST microstructural change and motor performance improvement. However, we did not set covariates in the linear regression, such as age and chronicity that can affect FA value, due to the small sample size. We need more studies with larger sample size to develop a better model for the relationship between brain microstructure and motor behavior.

T22: Trunk Muscle Activation Patterns during Walking with Robotic Exoskeletons in People with High Thoracic Motor-complete SCI

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Background: The International Standards for Neurological Classification of Spinal Cord Injury relies on sensory tests only to evaluate motor function in the thoracic segments of the spinal cord, which could result in uncertain assumptions about the motor function of these segments. Indeed, recent studies using targeted approaches to assess the trunk have revealed sparing of trunk muscle function in individuals with SCI classified with thoracic or cervical motor-complete injuries. Therefore, finding training techniques to recruit this preserved muscle function in the trunk could enhance their activation and potentially lead to better improvements in postural control and function. Robotic exoskeletons, such as the Lokomat and Ekso, are used in gait rehabilitation for people with SCI, but it remains unknown the extent to which they engage those trunk muscles that are normally activated during walking. The Lokomat and Ekso use different methods to provide gait training. The Lokomat provides gait training on a treadmill with the trunk passively supported by an overhead harness that provides weight support. However, the user's body is rigidly held within the Lokomat, which could imply lesser degree of recruitment of postural muscles. In contrast, gait training in the Ekso is provided overground and requires continuous participation from the users to maintain their balance while shifting their weight from one limb to the other in order to activate the Ekso's legs to walk. This mechanism could lead to better postural muscle activation.

Objective: To characterize and compare the activation patterns of the axial muscles during walking with the Ekso and the Lokomat in people with high thoracic motor-complete SCI.

Methods: 1 individual with T3 chronic motor-complete SCI. The participant performed 3 speed matched walking conditions: Lokomat-assisted walking (Loko-TM), Ekso-assisted walking overground (Ekso-OG), and Ekso-assisted walking on a treadmill (Ekso-TM). Electromyography (EMG) signals were recorded bilaterally from rectus abdominis (RA), external oblique (EO), and erector spinae (ES) and normalized to a standardized voluntary contraction (SVC).

Results: For Loko-TM condition, right RA mean EMG amplitude was 61% of SVC, EO 24% and ES 15%. In the left side, RA was 37%, EO 21% and ES 16%. For Ekso-OG, right RA was 141.3% of SVC, EO 238.9%, and ES 48.4%. In the left side, RA was 84%, EO 74% and ES 36.3%. For Ekso-TM, right RA was 187%, EO 356% and ES 63%. In the left side RA was 132%, EO 167% and ES 52%.

Conclusion: Based on the results, Ekso-assisted walking was better in activating trunk muscles than the Lokomat-assisted walking.

T23: PREP2: A refined algorithm for Predicting REcovery Potential of upper limb function after stroke

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Independence after stroke depends largely on the recovery of motor function. Accurate prediction of motor recovery may help clinicians and patients manage expectations, set realistic rehabilitation goals, and use their resources efficiently. However, accurate prediction is difficult for individual patients. We have previously described an algorithm for predicting potential for recovery of upper limb function for individual patients after stroke. The Predictng REcovery Potential (PREP) algorithm begins with a simple assessment of paretic shoulder abduction and finger extension strength (SAFE score out of 10), followed by transcranial magnetic stimulation (TMS) and magnetic resonance imaging (MRI), as required. Patients are predicted to have potential for a Complete, Notable, Limited or None recovery of upper limb function within 12 weeks. The PREP algorithm was developed with a dataset from 40 patients with first-ever ischaemic stroke. The aim of this study was to evaluate and refine the algorithm with a larger, more heterogeneous cohort. Inclusion criteria were confirmed stroke (ischaemic or haemorrhagic), new upper limb motor symptoms, and age at least 18 years. Previous stroke, thrombolysis and thrombectomy were allowed. Exclusion criteria were cerebellar stroke, contraindications to TMS and MRI for those patients who required these tests, reduced capacity for consent, and residing out of region precluding follow-up. The PREP algorithm was used to predict recovery of upper limb function for each patient. The Action Research Arm Test was used to measure paretic upper limb function 12 weeks post-stroke. A sample of 192 patients was recruited within 3 days of stroke (106 men, mean age 72 y, 100 right hemisphere), and 157 patients completed the 12 week assessment. The algorithm made correct predictions for 80% of patients. Of those with a Complete prognosis, 20% under-achieved and were in the Notable category at 12 weeks. Of the patients with a Notable prognosis, 50% over-achieved and were in the Complete category at 12 weeks. Using this information the algorithm was refined by combining the SAFE score with age (< 80, ≥ 80 years) to more accurately distinguish between patients with a Complete and Notable prognosis. With the revised algorithm, only patients with a SAFE score < 5 now require TMS, reducing the proportion of patients who need this test from over half to around one third. The revised algorithm is therefore more accurate and more efficient. The implementation of the PREP algorithm in clinical practice is described, with its potential clinical and economic benefits.

T24: Acupuncture in the treatment of fatigue in Parkinson's Disease: a pilot randomized controlled study

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Background: Fatigue is a common problem in patients with Parkinson's Disease, with reported prevalence of up to 70%. Fatigue can be disabling and has adverse effects on patients' quality of life. There is currently no satisfactory treatment of fatigue. Acupuncture is effective in the treatment of fatigue, especially that related to cancer. Its role in Parkinson's Disease-related fatigue is uncertain.

Aims: To evaluate the clinical efficacy of acupuncture treatment in Parkinson's Disease-related fatigue.

Hypothesis: We hypothesize that acupuncture is efficacious in alleviating Parkinson's Disease-related fatigue.

Design: A single centre, randomized, controlled study with two parallel arms.

Participants: Forty participants with idiopathic Parkinson's Disease will be enrolled.

Interventions: Participants will be randomized to receive verum (real) acupuncture or placebo acupuncture. The retractable non-invasive sham needle will be used in the placebo group. Intervention will be administered twice a week for 5 weeks. Acupuncture point selection is standardized for all participants and is based on Traditional Chinese Medicine principles underlying fatigue.

Main Outcome Measures: The primary outcome will be the change in general fatigue score of the Multidimensional Fatigue Inventory at week 5. Secondary outcome measures include other subscales of the Multidimensional Fatigue Inventory, Movement Disorders Society-Unified Parkinson's Disease Rating Scale, Parkinson's Disease Questionnaire-39 and Geriatric Depression Scale. All outcome measures will be assessed at baseline (week 0), completion of intervention (week 5) and 4 weeks after completion of intervention (week 9).

Results: To date, 23 participants have been recruited and 9 has completed the study. The mean age is 63.5±14.2 years, mean duration of Parkinson's Disease is 6.4±1.8 years and mean MDS-UPDRS score is 8.3±2.8. The mean General Fatigue score of the Multidimensional Fatigue Inventory is 13.5±4.6. No significant adverse event related to acupuncture is noted.

Potential significance: If the results are as expected, this study will provide preliminary scientific evidence for efficacy of acupuncture in Parkinson's Disease-related fatigue, and opens the door for a larger multicentre trial to be performed. In the longer term, it may lead to the integration of acupuncture in the care of patients with Parkinson's Disease.

T25: Kinect-based individualized upper extremity rehabilitation is effective in stroke: Outcomes and participants' perspective

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The low-cost virtual reality system such as Microsoft Kinect has become an increasingly popular tool for continued stroke rehabilitation outside of traditional rehabilitation. Despite its popularity, the therapeutic methods as well as the applicability of computer-based training such as the Kinect system transferring from the clinical to home setting remain largely unaddressed. The purpose of this study was to investigate the effectiveness of Kinect-based upper extremity (UE) training on functional performance in individuals with stroke in order to determine its potential for use in home environment. In addition, we examined stroke survivors' experience regarding Kinect-based training. **Methods:** Ten individuals (mean age 62.5±9.06 years) with chronic hemiparesis (7Lt,3Rt) were recruited from the local community. Subjects participated in Kinect-based UE training three times a week with a target duration of 4-5 weeks. To simulate the clinic to home transfer condition, the therapist guided participants at the initial three sessions, then withdrew input for the remaining of the training including interface with the system to start the exercise program. Outcome measures included Fugl-Meyer UE assessment (FM-UE), Wolf Motor Function Test (WMFT), Active Range of Motion for shoulder and elbow (AROM), the hand function portion of Stroke Impact Scale (SIS) and Confidence in Arm and Hand Function (CAHM). Participants' experience and feedback toward use of Kinect UE training was assessed using a structured questionnaire and a semi-structured interview. **Results:** Significant improvement was found in FM-UE, WMFT, AROM as well as the Hand function of SIS post-training (p<.05). In addition, clinical important differences were found in FM-UE and WMFT (Δ FM= 5.70 (3.47); Δ WMFT-TIME= — 4.45(6.02); Δ WMFT-FAS=0.29 (0.31)). All participants were able to run the system independently. Eight individuals reported increased use of the paretic arm in daily activities in the interview. Ninety percent of individuals found the training engaging and easy to follow reporting that the visual and auditory feedback were useful in training. All recognized the importance of the individualized modification made by the therapists at the beginning of training. **Conclusion:** We demonstrated that four weeks of Kinect-based UE training was able to provide clinically important and self-perceived improvements in arm function for chronic stroke survivors. Individualization of the Kinect exercises by therapists, at least in the first few sessions, appears important for use in the clinics/home setting.

T26: Deficits in automatic postural responses are related to cerebellar involvement in people with Multiple Sclerosis

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Introduction: Balance problems are prevalent in people with Multiple Sclerosis (PwMS); however, little is known about the mechanisms behind such deficits. We aimed to investigate ability of PwMS to predictively scale their postural responses to gradually increasing magnitudes of discrete surface perturbations. Given the cerebellum is responsible for predictive scaling or feedforward control of postural responses; we hypothesized that deficits in scaling postural responses to increased perturbation amplitudes will be related to the involvement of cerebellum in PwMS.
Methods: Subjects (24MS, 14Control) stood on a force platform that translated backwards in four blocks of predictable increasing amplitudes (3.6, 6.0, 8.4 and 12 cm). Each block consisted of five trials (total of 20 trials). To determine the role of feedforward mechanism, automatic postural responses to displacements was estimated as rate change of center of pressure under each foot before the feedback response could change the postural response. Predictive scaling was estimated by computing the slope of regression between early postural responses and gradually increased perturbation amplitudes. International Cooperative Ataxia Rating Scale (ICARS) was used as a clinical scale to assess the extent of ataxia. Diffusion weighted images (DTI) of brain were also acquired. Radial diffusivity (RD), an indirect neural marker of myelination, of cerebellar peduncles was calculated for each participant. Lower RD is interpreted as being indicative of better white matter tract microstructure.
Results: To date, we have analyzed the data of 9 MS and 9 control subjects. Control subjects exhibited better scaling of postural responses to the increasing magnitudes of the postural perturbations than PwMS (Regression coefficients: Control: 0.75±0.38; PwMS: 0.37±0.65). For PwMS, slope of the rate change of center of pressure with respect to the perturbation magnitude was negatively correlated with the ICARS scores (r=-0.65). ICARS scores were also correlated to the radial diffusivity of the cerebellar peduncles (r=0.5). However, the radial diffusivity of cerebellar peduncles was not related to the rate change of center or pressure (Control: 0.12; PwMS: 0.3).
Conclusion: Preliminary data suggests that deficits in predictive scaling of postural responses in PwMS seem to be related to the cerebellar involvement as evident by the relationship of ICARS and postural response scaling.

T27: An algorithm to predict recovery of independent ambulation after stroke

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Predicting the recovery of independent ambulation after stroke may help guide expectations for recovery and assist in realistic goal setting. The prediction of gait recovery has been limited to predicting whole group outcomes, or multivariable regression analyses which aim to explain the variance in recovery after stroke, but do not provide a means for predicting recovery in individual patients in a clinical setting. This study investigated a combination of clinical, neurophysiological and imaging assessments within 1 week of stroke as potential predictors for independent mobility at 12 weeks. The aim was to create an algorithm to predict which patients will recover independent ambulation. An initial cohort of 35 patients with lower limb weakness was recruited within 3 to 7 days of ischaemic or haemorrhagic stroke (16 men, mean age 70 years, 19 right hemisphere). Baseline clinical assessments were conducted at 3 days and 1 week after stroke. These included stroke severity, strength, lower limb impairment, trunk control, balance and current ambulation. In addition to clinical measures, transcranial magnetic stimulation (TMS) was used between days 5 - 7 to assess the functional integrity of the corticospinal tract (CST) by attempting to elicit a motor-evoked potential (MEP) in the affected tibialis anterior muscle. Magnetic Resonance Imaging (MRI) was conducted at 7-10 days after stroke to assess structural integrity of the CST. The primary endpoint was independent mobility at 12 weeks, defined as a Functional Ambulation Categories (FAC) score of 4 or 5. At 1 week after stroke, 16 patients had an FAC score of 0 (unable to mobilise or requiring at least 2 people to assist), 10 required assistance or supervision to mobilise (FAC 1,2,3) and 7 had already regained independent mobility (FAC 4,5). At 12 weeks, 23 were mobilising independently, 4 required assistance and 2 were unable to mobilise. Six patients were lost to follow up due to death or illness. Preliminary data analysis indicates that an algorithm based on clinical assessments alone at 1 week after stroke may predict which patients will or will not recover independent ambulation. This differs from previous work in the upper limb in which a combination of clinical assessment, TMS and MRI is recommended. A second cohort of 18 patients (8 men, mean age 70 years, 9 right hemisphere) was recruited to test the proposed algorithm. Patients in the second cohort are currently completing primary endpoint assessments. The findings from this study are expected to provide evidence for the use of a simple, clinically useful algorithm for predicting which patients will recover independent ambulation after stroke.

T28: Preliminary Evidence of Interlimb Transfer after Locomotor Training in Individuals with Chronic Spinal Cord Injury

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Research Objectives: The purpose of the case series was to document upper extremity function in individuals with chronic cervical incomplete spinal cord injury (iSCI) participating in overground locomotor training (OLT). Intensive exercise training is known to promote cortical plasticity which may account for inter-limb transfer. Although treadmill training has been shown to increase corticomotor excitability to hand muscles, similar transfer of benefits from lcomotor training from lower to upper extremity function has not been reported in this population.

Design: Case Series

Setting: Human Performance Research Laboratory, George Mason University.

Participants: 5 males, 1 female, Age: 19-67, Injury Level: C3-C6, ASIA C and D

Intervention: 12 weeks of OLT occured 2x/week for 90 minutes/session. Weekly sessions alternated emphasis on linear and multiplanar movements related to walking. Training was based on principles of progressive overload, task-specificity, and task variation within a part-whole practice paradigm

Main Outcome Measure: Jebsen Taylor Hand Function Test (JTHFT).

Results: In total, 5 of 6 participants demonstrated improved times on the JTHFT following OLT. Time improved in 4 of 6 participants: 7.3 seconds (4.6%), 18.8 seconds (12.4%), 60.9 seconds (12.3%), and 21.7 seconds (13 %). Three out of 6 participants reached minimal clinically important difference estimated at 20.8s. Of the 2 subjects who did not improve , one participant continued with OLT for an additional 12 weeks and subsequently improved from the initial trial by 26.7s (14.8%).

Conclusion: OLT may contribute to modest improvements in upper extremity function. Alternately, greater ability to participate in activities of daily living after OLT may encourage greater use of UE in daily activity. Future studies are needed to confirm these findings and determine potential mechanisms of change.

Key Words: spinal cord injury, locomotor training, upper extremity function, inter-limb transfer

T29: Measuring Mirror movements in children with unilateral cerebral palsy

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Background
Mirror movements (MM) are a physiological feature in young children and gradually disappear during the first decade of life. However, children with unilateral cerebral palsy (UCP) often present with more pronounced MM, whereby MM in the non-paretic hand are correlated with poor hand function. Conversely, MM in the paretic have been related to hand to the brain lesion type and reorganization of the corticospinal tract (Klingels et al. 2015).

Aim
To date, studies have mostly used a simple ordinal rating scale to assess MM (Woods & Teuber 1978). We propose a quantitative assessment based on a unimanual repetitive squeezing task with whole-hand grip force measurements.

Method
We assessed 14 children with UCP (age 7-12 years, MACS level I to III). During the squeezing task, forces were simultaneously recorded from both hands using custom handles. Children were instructed to launch a spaceman over a meteorite by repetitively squeezing one of the handles during 3x30sec at a frequency of 0.67Hz (total of 60 squeezes, minimum force 15% of the maximum voluntary contraction (MVC)). Force profiles were analyzed and compared to clinical scoring of MM (Woods & Teuber 1978) during fist opening and clenching.

Result
MM in the paretic hand occurred significantly more frequently, showed a higher synchronization, and a stronger delay with respect to the active hand compared to MM in the non-paretic hand ($p<0.05$). Correlation analyses showed no significant correlation with age (rho= -0.36 to 0.16, $p>0.2$).

Ten children showed frequent and strong MM in their paretic hand (Median r_{cross} 0.74); 3 children had frequent but mild MM (Median r_{cross} 0.45); and 1 child was categorized as no MM in the paretic hand. Five children showed frequent and strong MM in their non-paretic hand (Median r_{cross} 0.65); 4 children had frequent but mild MM (Median r_{cross} 0.49); and 5 children were categorized as no MM in the non-paretic hand.

The sensitivity analyses showed maximum sensitivity (100%) and minimum false negative rate (0%) for the categorization of MM in the paretic hand. Categorization of MM in the non-paretic hand showed sensitivity of 89%, with a false negative rate of 11%.

Conclusion
We present a clinically feasible measurement to quantify MM in children with unilateral CP and to categorize MM based on their frequency and amount.

We found significantly more (frequency), stronger (amount), and more delayed MM in the paretic hand compared to the non-paretic hand during the repetitive squeezing task.

T30: Efficacy and safety of abobotulinumtoxinA (Dysport®) in adult hemiparetic patients with upper limb spasticity previously treated with Botulinum Toxins

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Introduction: Patients with upper limb spasticity (ULS) often require repeat botulinum neurotoxin (BoNT) injections, and may have to switch BoNT products during their long-term management.

Objective: This subanalysis of a double-blind, placebo-controlled study study evaluated abobotulinumtoxinA (Dysport) treatment in adult hemiparetic patients who had previously received other BoNT products for ULS.

Methods: 105 of 243 enrolled patients had previously been treated with another BoNT product for ULS. Patients were randomized (1:1:1) to a single injection of abobotulinumtoxinA 500U or 1000U or placebo.

Results: In this subgroup of 105 previously–treated patients, mean±SD age was 52±14y, 62% were male and the ULS-etiology was stroke (87%, mean 6y post-event) or traumatic brain injury (13%, mean 7y post-event). Most (88%) patients had previously received onabotulinumtoxinA, (mean/max dose 292U/800U) and 16% had previously received IncobotulinumtoxinA (mean/max dose 312U/1000U). Of these, 69 patients were randomized to 500U (n=37) or 1000U (n=32) of abobotulinumtoxinA. At 4 weeks post-injection, 78% patients demonstrated ≥1 point improvement in Modified Ashworth Scale scores (vs. 25% for placebo) and 80% showed overall clinical improvement (mean improvement of ≥1 grade in physician's global assessment). The Tardieu scale 'angle of catch' improved in finger, elbow and wrist flexors by 18–46° (vs. -1–11° [placebo]) and spasticity angle improved by 15–31° (vs. -3– -11° [placebo]), resulting in a gain in extension (AROM) from 12–19° (vs. -1–4° [placebo]). No unexpected safety events were observed.

Summary/conclusions: In this subpopulation of previously-treated hemiparetic adults, abobotulinumtoxinA (500/1000U) injections improved muscle tone, spasticity, active movement for overall clinical improvement.

T31: Effects of antagonist activation on motor cortical excitability of the tibialis anterior

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INTRODUCTION: Transcranial magnetic stimulation (TMS) has been extensively used to non-invasively evaluate corticospinal circuitry. However, the majority of studies have investigated responses from the upper extremity. There are few investigations lower limb muscles, and on how agonist or antagonist muscle activation influence lower extremity TMS-evoked responses. The objective of this study was to evaluate whether antagonist muscle activation influences TMS-evoked motor evoked potential (MEP) amplitudes recorded from the tibialis anterior (TA) muscle.
METHODS: 13 young, neurologically-unimpaired adults (3 male, 10 female, ages 23-35 years) received TMS pulses delivered at 120% resting motor threshold over the TA hotspot in the left motor cortex). TMS-evoked MEPs were recorded from the TA muscle using surface electromyography (EMG) during 3 conditions: 1) TA and soleus at rest (rest), 2) TA activated at 10% maximum EMG activation (agonist-on), and 3) soleus activated at 10% of maximal activation (antagonist-on). A repeated-measures ANOVA with pair-wise post-hoc comparisons was performed to compare with post-hoc pairwise comparisons were performed to compare TA MEPs as well as pre-stimulus background EMG amplitude during the agonist-on and antagonist-on conditions with the resting condition.
RESULTS: TA MEPs were significantly greater during TA activation (agonist-on) versus rest ($p<0.05$). TA MEPs were significantly larger during soleus activation condition (antagonist-on) compared to rest. Comparison of background EMG amplitudes confirmed that the TA background activation was greater during agonist-on versus rest, and that Soleus background activation was greater during antagonist-on versus rest. There were no differences in TA background EMG during the rest versus antagonist-on conditions.
DISCUSSION: A low-level activation of the targeted muscle is known to enhance cortical excitability that results in larger TMS-evoked MEPs. Our results show that during the measurement of TMS-evoked MEPs, activation of the antagonist muscle (soleus) also enhances TMS-evoked MEPs recorded from the TA muscle. Interestingly, cortically-evoked MEPs from the agonist (TA) muscle did not show an effect of spinal reciprocal inhibition from the antagonist (SOL), suggesting that the spinal-level reciprocal inhibition may have been counteracted by other facilitatory influences from descending projections onto the alpha motor neuron. Ongoing analysis is exploring whether cortical excitability of proximal lower limb muscles (e.g. quadriceps) is influenced differently during contraction of the TA versus Soleus. Previous studies suggest that TA and Soleus may be controlled by overlapping cortical representations. Additionally, the location of the lower extremity motor representation deep within the inter-hemispheric fissure may result in concurrent activation of descending cortico-motor projections to both the TA and Soleus during supra-threshold TMS delivered over the TA hotspot. Future studies will evaluate the effects of neurologic impairment, gait training, and agonist-antagonist co-activation on lower limb cortical excitability.

T32: Manipulating chronic inflammation and neural plasticity away from the site of rodent spinal cord injury

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Lateral hemisection spinal cord injury (SCI) at T10 produces nociceptive hypereflexia in the cutaneus trunci muscle (CTM) reflex and the sprouting of nociceptive afferents in dorsal cutaneous nerves (DCNs), the afferent limbs of the reflex, 6 weeks after SCI, both above (T7) and below (T13) the level of injury, on both sides of the spinal cord. The numbers of Iba1+ microglia/macrophages, but not GFAP+ astrocytes, are also increased at T7 and T13 at this chronic time point following T10 SCI. Because a persistent inflammatory environment following SCI is thought to be related to the development of chronic neuropathic pain, we hypothesized that a selective soluble Tumor Necrosis Factor (TNF) blocker, XPro1595, could modulate chronic inflammation in these spinal segments away from the injury and alter the neural plasticity seen there. XPro1595 has been shown to impact inflammatory cell biology and could impact neural transmission by blocking microglial-derived TNF effects on glutamate and GABA receptors. Long Evans female rats (n=19) were subjected to a T10 lateral hemisection SCI and injected with either 3 mg/kg or 10 mg/kg of XPro1595 subcutaneously every third day starting the day of surgery. Therapeutic levels of XPro1595 were detected in plasma, cerebrospinal fluid (CSF), brain, and spinal cord segments (T7, T10, T13) 2 weeks after SCI in a dose-dependent manner. Additional animals (n=8) were then treated at 10 mg/kg for 6 weeks following SCI. This chronic XPro1595 treatment reduced the number of Iba1+ microglia/macrophages at T7 to uninjured levels and at T13 to lower than uninjured levels 6 weeks after T10 SCI. XPro1595 treatment also reversed injury induced nociceptive hyperreflexia, returning T7 DCN evoked CTM reflex sizes to uninjured values and causing hyporeflexia relative to the uninjured state in T13 DCN evoked reflexes. The effect of 6 weeks of XPro1595 on nociceptive afferent sprouting in T7 and T13 DCNs is being evaluated. Gene expression levels were also investigated at T7 and T13 in uninjured, T10 SCI, and T10 SCI with XPro1595 treatment animals using qRT-PCR arrays. Groups of genes related to inflammation, neurotrophism, neural transmission, synaptic plasticity, and myelination are being evaluated in particular. This study is the first we know of to examine the relationships between inflammation, reflex physiology, afferent anatomy and genetic changes associated with neural plasticity in the spinal cord away from the site of injury.

T33: Does task-specific training improve upper limb performance in daily life post-stroke?

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Background: A common assumption is that changes in upper limb (UL) capacity, or what an individual is capable of doing, translate to improved UL performance in daily life, or what an individual actually does. This assumption needs to be explicitly tested for individuals with UL paresis post-stroke.

Objective: To examine changes in UL performance after an intensive, individualized, progressive, task-specific UL intervention for individuals at least 6 months post-stroke. We tested the assumption that increased UL capacity translates to increased UL performance and also examined the effect of dose (i.e. amount) of task-specific movement practice on UL performance in daily life.
Methods: Secondary analysis on 78 individuals with UL paresis who participated in a Phase II, single-blind, randomized parallel dose-response trial. Participants were enrolled in an individualized, graded, progressive task-specific intervention for 8 weeks. Participants were randomized into 1 of 4 treatment groups with each group completing different amounts of UL movement practice. UL performance was assessed with bilateral, wrist-worn accelerometers once a week for 24 hours throughout the duration of the study. Six accelerometer variables were calculated from the accelerometer data, each quantifying different aspects of UL movement. Growth curves were tested for six accelerometer variables using hierarchical linear modeling, with individual time trajectories nested within participants. The moderating effects of stroke chronicity, baseline UL capacity (measured by Action Research Arm Test), concordance (i.e. dominant side = affected side), and independence with activities of daily living were also modeled.

Results: No changes in UL performance were found on any of the 6 accelerometer metrics used to quantify UL performance. Neither changes in UL capacity nor the overall amount of movement practice influenced changes in UL performance. Stroke chronicity, baseline UL capacity, concordance, and ADL status significantly increased the baseline starting points (intercepts) but did not influence the rate of change (slopes).

Conclusions: The direct benefits of an intensive UL intervention in the clinic do not appear to translate to improved UL performance outside the clinic.

T35: Evaluation of a Unique Approach to Balance and Mobility Training Poststroke: Falls Based Training (FBT) Protocol

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BACKGROUND AND PURPOSE: Treadmill-training protocols that use varying levels of body-weight support (BWS) and/or robotic-assistive devices are common rehabilitation approaches,to improve poststroke balance and walking outcomes. However, comparison of BWS treadmill-training paradigms that incorporate skills-based walking challenges, to walking without external hand support, has not been explored. The purpose of this study was to examine the performance characteristics of individuals with walking-speed deficits poststroke, who underwent two training protocols of similar intensity. The first consisted of hands-free (HF), self-driven walking while the second integrated skills-based (SB) challenges, required for functional walking.
STUDY: Performance measures during a 6 week, single-blinded, parallel randomized controlled training trial
HYPOTHESIS: We expected the amount of BWS needed by both training groups to decrease on a weekly basis. We also expected that the SB group would cover less distance during each training session, but would improve more in their weekly averages for daily assessment at comfortable walking speed (CWS), compared to the HF group.
METHODS: The study involved treadmill training with BWS provided by a robotic-assistive device (KineAssist) for two active intervention groups (HF and SB). The device provided both groups with BWS, and a safe hands-free walking environment (i.e. no handrails or external support mechanisms). Twenty-six individuals poststroke were randomly allocated to each group. Each group completed three, thirty-minute walking sessions at a 60-80% target heart rate, for six weeks. The HF group walked at their CWS for the full duration of each training session, while the SB group completed three of nine randomized walking skills during each session. The nine skills performed were as follows: long stepping, speeding up and slowing down, head turns, variable-walking speeds, hurdles, narrow stepping, perturbations during walking, backward walking, and walking with foam shoes. Individual BWS requirements, total steps, distance covered, and CWS were determined for each session.
OUTCOMES: Training performance characteristics such as weekly BWS levels, CWS, weekly distance traveled, and weekly total steps.
RESULTS: As hypothesized, both groups progressively decreased their BWS requirements. At Week 1, the HF group required 8.2 % ± 2.3 SEM, vs. the SF group was 6.4 % ± 2.7 SEM, decreasing to 2.6 ± 1.1 SEM, and 0.3 ± 0.3 SEM at Week 6, respectively. CWS for the HF group increased from 0.43 ± 0.06 SEM to 0.53 ± 0.07 SEM. While, the SB group increased from 0.4 ± 0.04 SEM to 0.6 ± 0.1 SEM. No significant difference was observed in distance traveled or total number of steps taken between groups. No serious adverse events were reported in either arm of the trial.
CONCLUSIONS: Both training paradigms exhibited improvement in performance during training sessions. We demonstrated that both HF and BS training paradigms were feasible, challenging, and potentially effective at improving walking performance in individuals poststroke.

T36: Effectiveness of a Robot-aided Somatosensory Training Program on Proprioception in Chronic Stroke

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Proprioception refers to the perception of limb motion or position and the orientation of one's body in space. Nearly 50% of stroke survivors showed proprioceptive deficits (e.g. Carey & Matyas 2011), which is associated with poor upper limb motor function impairing many activities of daily living. Thus, improving proprioception could be an additional route to enhance motor recovery. We designed a robot-aided training regimen that required users to make active wrist movements without vision. User grasped the handle of the robot and performed wrist adduction/abduction movements to tilt a virtual board on which a ball rolled. Aim was to roll the ball to a target on the board. Real-time, vibro-tactile feedback about joint position and velocity was provided to the forearm. METHODS: Two functionally independent yet with limited affected arm use, chronic stroke participants were recruited (Fugl-Meyer Assessment: 65/66 & 27/66). Four healthy participants (mean age ± SD: 26.4 ± 3.3 years) served as controls. Participants completed two training sessions on two consecutive days (total training time: 1 hour). A familiarization phase with vision was completed prior to training, while training was performed without vision. Task difficulty increased as the participants succeeded. Assessment was conducted before, immediately after, and two days after the intervention. Outcome measures were 1) wrist position sense acuity defined as the just-noticeable-difference threshold of wrist abduction/adduction and 2) the latency (time to peak) of a somatosensory-evoked potential proprioception-related component (N30). Controls were assessed only before and after the intervention. RESULTS: The more severely impaired stroke participant improved and maintained his wrist position acuity (Pretest: 5.4°; Day 2 (End of training): 3.3°; Day 5: 2.3°). The less affected stroke participant did not show proprioceptive deficits but performed within the range of the control group (Pretest: 0.8°; Day 2: 0.8°, Day 5: 1.2°; Control group: Pretest mean ± SD: 2.0° ± 1.2°; Day 2 mean ± SD: 1.4° ± 0.5°). The N30 latencies were within the known normal range throughout the tests in both groups. CONCLUSION: Robot-aided proprioceptive training may improve proprioceptive acuity in chronic stroke participants with known proprioceptive impairment. If the effectiveness on improving the proprioceptive and motor function is substantiated in a larger population, the proposed training could be a treatment approach for clinical practice.

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T37: Combined Cortical and Spinal Direct Current Stimulation in Incomplete Spinal Cord Injury: case series

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OBJECTIVE

The purpose of this pilot study is to demonstrate that increasing excitability of the corticospinal tract at cortical motor region and at cervical spinal cord level (below injury) with transcranial direct current stimulation (tDCS) and transcutaneous spinal direct current stimulation (tsDCS) combined with robot-assisted (R-A) arm training will provide greater improvement in contralateral arm and hand motor functions when compared to combined tDCS and robot-assisted training in patients with incomplete spinal cord injury (SCI).

METHODS

We report results from two male adult participants with tetraplegia due to chronic, incomplete cer-vical spinal cord injury. Case 1: 59 yo, married, traumatic SCI due to fall, presented American Spinal Cord Injury Impairment Scale grade D at C3-C4 level of injury. Mild increase in muscle tone in majority of arm and finger muscles were present. Case 2: 64 yo, divorced, traumatic SCI due to fall from bike at C3-C6 level, with an ASIA Impairment Scale grade D. At the time of en-rollment Case 1 was 84 months and Case 2 was 60 months post-injury. Both participant had min-imal movement in the fingers and presented mild to moderate increase in muscle tone in majority of arm and finger muscles.

Intervention: during the first 20 minute participants received 20 minutes anodal tDCS (2 mA) on motor cortex (M1) contralateral to their trained side which was followed by anodal tsDCS (2.5 mA) unilateral to their trained arm for first 15 minutes and simultaneous R-A training for 60 minutes. Treatment was administered at an intensity of 5 sessions per week for 2 weeks. Arm and hand functions and motor evoked potential (MEP) were measured before and immediately after treat-ment.

RESULTS

Ten sessions of treatment has produced slight improvement in arm and hand functions as meas-ured with GRASSP, grip and pinch strength. MEP changes were not significant. Treatment proto-col were well tolerated.

CONCLUSION

Neuromodulation of executive motor functions at cortical and spinal level when coupled with high intensity repetitive arm training may be a promising strategy in improving arm and hand functions in persons with incomplete tetraplegia. However further research is needed to study polarity de-pendent effects of combination therapies.

Keywords: Spinal Cord Injury, DTI, fMRI, tDCS, tsDCS

T38: Treatment Characteristics of Post-Stroke Adults Diagnosed with Spasticity Among Commercially and Medicare Insured Populations

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Objective: To understand real-world botulinum toxin A (BoNT-A) and non-toxin treatment characteristics of post-stroke adult patients diagnosed with spasticity.

Design: Retrospective analysis.

Setting: Commercial and Medicare claims data.

Participants: Initial analysis included 117,173 adult (≥18 years) patients with an incident stroke between 1/1/2010 – 12/31/2012. Patients included were continuously enrolled in their healthcare plan for ≥12 months prior to and ≥24 months post-stroke.

Interventions: Not applicable.

Main Outcome Measures: Patient demographics, treatment dynamics and characteristics among spasticity patients receiving BoNT-A or non-BoNT-A therapy. Spasticity was defined as having ≥1 medical claim with International Statistical Classification of Diseases (ICD-9) codes for spasticity (342.10, 342.11 and 342.12) within the 24 months post-stroke.

Level of Evidence: III

Results: The claims data analyzed included 1,948 (1.66%) post-stroke patients diagnosed with spasticity. BoNT-A therapy was initiated in 287 (14.7%) of these patients. These patients did not have prior history of BoNT-A use between date of stroke diagnosis and spasticity diagnosis. Mean time to BoNT-A treatment initiation from spasticity diagnosis was 67.3 days [125.1]. 202 (70.4%) BoNT-A treated patients received a second BoNT-A treatment, with mean time to second treatment equaling 119 days [70.7]. In addition to BoNT-As, other treatments used included physical therapy (67.9%) and oral medications (40.1%).

1,371 (70.4%) post-stroke patients with spasticity utilized non-BoNT-A treatments. In patients with observable treatments (65.7%), therapy usage was low; 57.2% used physical therapy and 18.5% used oral medications. Patients <65 were more likely to receive physical therapy than patients ≥65 (65.8% vs. 49.9%).

Conclusions: The majority of post-stroke patients with spasticity do not receive BoNT-A therapy. The most commonly utilized spasticity treatment by these patients is physical therapy. The minority that did receive BoNT-A therapy were found to continue with consecutive treatments. Further education is needed to inform healthcare providers and patients about available treatments.

T41: Microdermabrasion facilitates direct current stimulation by lowering skin resistance

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Background: Skin injury is one of the most common concerns with the use of non-invasive electrical stimulation methods, especially direct current stimulation. Skin injury can manifest as a mild electric burn at the superficial layer of dermis as a result of conversion of electric energy in the presence of high skin resistance.

Objective/Hypothesis: In this study, we evaluated the effect of skin preparation procedures, namely microdermabrasion (scraping of skin) and/or sonication (using ultrasound waves) on skin resistance. We also evaluated the perceived changes in direct current stimulation (DCS)-related sensations.

Methods: Twenty healthy subjects (10 males, 10 females) of different ethnicity with no visible forearm skin injuries or defects participated in the study. Over two visits, they received four skin preparation procedures (microdermabrasion, sonication, both or sham) on their forearms. The resistance and temperature of the forearm skin was measured before and after the skin preparation procedure when they briefly underwent DCS for a few minutes. Subjects were asked DCS-related and skin preparation-related questions throughout the procedure.

Results: Microdermabrasion led to significant decrease in skin resistance (1.6 KΩ on average, $P<0.001$). Sonication at 3 MHz frequency, on the other hand, did not lead to significant decrease in skin resistance ($P=0.6233$ after Tukey-Kramer adjustment). We did not observe any significance change in temperature at skin-electrode interface. White females, and white subjects in general, were more likely to have tingling. Older subjects (≥ 29 years old) were more likely to have tingling, itching and burning when compared with younger subjects (<29 years old). Temporary, reversible skin redness was observed across all subjects.

Conclusions: Use of microdermabrasion is a potential method to decrease the chances of electrical-stimulation-related skin injuries. Microdermabrasion decreases skin resistance by partially removing the stratum corneum layer of epidermis, the outermost layer of skin. There was no significant difference in subjective sensations in microdermabrasion group when compared with other groups.

T42: Optimizing Extraction of the Corticospinal Tract Using Diffusion-Weighted Imaging

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Background: Information about the structural integrity of the corticospinal tract (CST) can improve our ability to identify recovery potential in people with upper limb impairment, especially those with severe stroke. Despite this, there is no universally accepted method for extracting the CST data from diffusion-weighted imaging (DWI).

Aim: The current study investigated key regions of interest and tractography approaches to identify the method to generate data from the CST that led to the greatest number of tracts to be extracted. Tract number was chosen as it minimised missing data, especially within the severe group. We also sought to determine if severity of upper limb impairment influenced this outcome.

Methods: Thirty individuals in the chronic phase (>6 months) of stroke recovery: 15 with mild to moderate upper limb impairment (Fugl Meyer Upper Limb score >30), and 15 with severe upper limb impairment (Fugl Meyer Upper Limb score ≤30). All individuals underwent diffusion weighted imaging in a 3T magnetic resonance imaging (MRI) center. Images were motion corrected and diffusion behaviour modelled using constrained spherical deconvolution (CSD). Three 'AND' regions of interest (ROI) were delineated in the lesioned hemisphere in the axial plane around the posterior limb of the internal capsule (PLIC) at the level of 1) corona radiata, 2) anterior commissure, and 3) pyramids in the pons. On the basis of these ROIs, subsequent tract reconstructions of descending CST fibres were produced using CSD-based deterministic whole-brain fibre tractography. The number of tracts were extracted for the 'whole' tract or a 'segment' of the tract for three combinations of ROI locations: 1) corona radiata + anterior commissure; 2) corona radiata + anterior commissure + pyramids in the pons; and 3) anterior commissure + pyramids in the pons. The segmented tract method constrained extracted tracts to only those fibres that passed between the identified ROIs, whereas the whole tract method afforded tracts to extend upstream or downstream of the ROIs. Using tract number, we completed a 3-way mixed model repeated measures ANOVA.

Results: There was no effect of tract method X severity ($p = 0.398$), or tract method X location of ROI extraction X severity ($p = 0.445$). However, there was an effect of location of ROI extraction X severity ($p = 0.003$), whereby the corona radiata + anterior commissure method generated the greatest number of tracts.

Discussion: This study demonstrates that location of ROI influences the number of tracts extracted. As such, differential extraction of residual CST integrity across studies to date may be leading to variation in research results. The next steps for the field are to adopt consistency in CST extraction method to enhance pooling of data across studies.

T43: Neurobehavioral validation of an individualized indicator for the presence of incidentally developed explicit awareness in motor learning

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When a patient is initially learning a motor task in a rehabilitative setting, movement patterns can be introduced with direct instruction to the task or more of a discovery learning paradigm. In both methods, patients will experience implicit learning, with some patients developing an explicit awareness of specific motor patterns. Previous studies have suggested that the presence of such explicit awareness during motor learning can have detrimental effects on performance, consolidation and generalization, all of which are important to successful rehabilitation. However, the majority of these studies have utilized an explicit motor learning paradigm with which to elicit, and explore, the effects of explicit awareness. Explicit awareness developed incidentally is far less studied due to the challenging nature of identifying when a subject has acquired such awareness without interfering with the learning process. In addition, the timing of when such awareness occurs will vary between subjects, adding additional challenges for group analysis. Therefore, the aim of this study is to provide neural validation of an individualized behavioral indicator for the presence of incidentally developed explicit awareness of a motor sequence. Twenty, naïve subjects were exposed to a visuomotor serial reaction time task containing a seven-key repeating sequence of which they had no explicit awareness. At the end of the experiment, subjects were asked if they could identify and recall the embedded sequence. Subject response latency and accuracy, along with recall accuracy, were recorded and compared to the previously identified behavioral indicator for the presence of awareness. Additionally, EEG measurements were recorded to identify changes in coherence in visuomotor circuits over the course of the experiment. As a person becomes aware of the sequence, motor behavior can shift from an externally guided reliance on the visual cue to a more internally-driven execution of the learned motor sequence. Findings identify a strong relationship between increased coherence in mesial premotor networks and behavioral indicators predicting explicit awareness, which provides a valuable tool to further explore the impact of incidentally developed awareness in rehabilitative settings.

T44: Effects of unilateral real-time gait biofeedback on propulsive forces during walking

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INTRODUCTION: Reduced push-off force generation is an important post-stroke gait impairment that negatively impacts walking function, and is the target for rehabilitation interventions. During normal locomotion, push-off forces are modulated with variations in speed and slope. However, the extent to which able-bodied or individuals with hemiparesis can learn to selectively increase push-off forces from one leg is unknown. Here, we present findings from two experiments that test the short-term effects of training with real-time ground reaction force gait biofeedback from on gait biomechanics.

METHODS: In the 1st experiment, 7 young, neurologically-unimpaired individuals participated in 11-minutes of gait training comprising real-time visual and auditory biofeedback aimed at increasing anteriorly-directed ground reaction force (AGRF) in the targeted (right) leg. Push-off forces were recorded from each limb during walking without biofeedback before (pre-training) and after the biofeedback delivered in an intermittent, faded feedback schedule (post-training). Retention tests were performed without biofeedback after a 2-minute standing break. In the 2nd experiment, 7 individuals with chronic post-stroke hemiparesis participated in 18-minutes of gait training with AGRF biofeedback. Push-off forces and gait biomechanics were recorded at pre-training, immediately after training, and during retention tests performed at 2, 15, and 30-minutes post-training.

RESULTS: In experiment 1, compared to AGRFs generated during the pre-training gait trials, neurologically-unimpaired subjects demonstrated a significantly greater AGRF in the targeted (right) leg during and immediately after training ($p<.05$). Additionally, subjects continued to demonstrate 20-30% greater AGRF production in the targeted leg after two rest periods, showing short-term recall of the gait pattern learned during the biofeedback training. No significant effects of training were observed on the AGRF in the non-targeted limb, showing the specificity of the effects of biofeedback toward the targeted limb.
Data from experiment 2 are currently being analyzed, but preliminary analysis on 2 post-stroke individuals who underwent biofeedback training similar to experiment 1 demonstrated a 28-49% increase in paretic limb push-off immediately after biofeedback training and at the 5-minute retention test. The increased paretic push-off was accompanied by 15% longer paretic step lengths and a 32% increase in peak trailing limb angle at the 5-minute retention test. Ongoing data-analysis in individuals post-stroke is evaluating the effects of the biofeedback training on kinetic and kinematic gait deficits post-stroke.

DISCUSSION: We demonstrated the specificity and short-term effects of using unilateral AGRF biofeedback to target push-off, a finding which may have utility as a training tool for individuals with unilateral gait deficits such as post-stroke hemiparesis. As a rehabilitation tool, real-time biofeedback offers the advantage of providing accurate and immediate knowledge of performance during training that might enhance motor learning. Future studies will investigate optimum dosing regimens and long-term effects of real-time gait biofeedback training in individuals with post-stroke hemiparesis.

T45: Former unilateral amputees exhibit bilateral differences in the control of reach-to-grasp actions

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Upper limb amputation is associated with reorganization of the somatosensory system, where changes are detected in the cerebral hemispheres contra- and ipsi-lateral to the trauma. Some of these changes persist even years after the reversal of amputation through hand replantation or transplantation. We used high spatiotemporal-resolution motion analysis to test the hypothesis that, as a result of limitations in somatosensation, these individuals are heavily dependent on visual feedback of the limb to coordinate reach-to-grasp actions. This study included six control subjects, two hand replants, and one hand transplant recipient (the latter evaluated longitudinally). All were right-handed and, with the exception of one of the replants, had their left hand affected. Subjects grasped cubes of three different sizes, with (light) and without (dark) vision of the hand. Importantly, objects were luminescent and thus always visible. We measured: the peak (PGA) and timing (tPGA) of the grip aperture (measured between index finger and thumb), and the peak (PTV) and timing (tPTV) of the transport velocity of the hand. The values for the right and left hands of the patients were compared to the 95% CI for the mean of the control group, matched by hand dominance. Controls. The PGA and tPGA scaled with the object size in both vision conditions. The PGA was smaller in the dark, with a larger decrease in the left than in the right hand. The PTV was ~15% larger for the dominant right [51.77 ± (SD) 3.28 cm/s, CI: 48.33 - 55.21] vs. the left hand (45.12 ± 2.30 cm/s, 42.71 - 47.54), and ~10% larger in the dark (50.75 ± 4.36 cm/s, 46.17 - 55.33) than in the light (46.15 ± 3.29 cm/s, 42.69 - 49.60). Patients. As with controls, PGA scaled with object size and was also smaller in the dark. However, when the smaller objects were grasped with the affected hand, patients did not scale the PGA to the same extent as the controls. The PTV was higher than the 95% CI of controls with the affected and unaffected limb and for both vision conditions. In contrast to controls, in the affected hand, the values of PTV of all patients were similar in the light and dark. For the unaffected hands of the two replants, the PTV was higher in the dark vs. light, while in the transplant, the PTV was similar in both conditions. Although our hypothesis was not supported, we observed unexpected differences in performance with the unaffected limb in all three patients. While further work is needed, we speculate that these changes in the sensorimotor control of the healthy limb may be attributable to documented bilateral reorganizational changes within sensory and/or motor cortex following unilateral deafferentation.

T46: Effect of Stroke on Dynamic Forefoot Ground Reaction Force and Electromyography Activation in Tibialis Anterior during Isokinetic Passive Ankle Movement

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Background: Stroke survivors showed a restricted range of motion (ROM) and increased joint stiffness due to structural alterations in skeletal muscles. Ankle joints in stroke survivors have abnormal muscle activations during gait and inadvertently affect gait stability and symmetry due to decreased ground reaction force and reduced dorsiflexion during a gait phase. So we developed a robotic device for ankle muscle training, Ankle Muscle Trainer (AMT), which provides isokinetic passive ankle movements in sagittal and frontal plane, and simultaneously measures the dynamic ground reaction forces. However little is known about the effect of decreased ROM in stroke survivors on the ankle muscle activation pattern during passive ankle movement. In this study, the relationship of forefoot ground reaction force during isokinetic passive ankle dorsi-/plantarflexion was investigated with active ankle ROM and the electromyographic activation pattern in ankle dorsiflexor, Tibialis Anterior. Secondly the parameters which well predicted TA muscle activation level during isokinetic passive ankle movement were investigated.

Methods: 11 healthy elderly (76.6± 3.4 yrs, F:7) and an age-matched stroke patient (76 yrs, duration 14.1yrs, M) participated in this trial. All participants had a self-evaluation of active dorsi-/plantarflexion using AMT, whose movement was pivoted along the talocrural joint while participants were comfortably seated with knee 90 degree flexed. Then the ankle was passively moved at least 8 times the full range of ankle planar-/dorsiflexions at 20 deg/s. Four EMG markers were attached on medial gastrocnemius, lateral soleus, peroneus longus, and tibialis anterior, sampled at 2k Hz. Tibialis Anterior (TA) muscle activation level was normalized by maximum contraction during active dorsiflexion and was analyzed by using receiver operating characteristics plot and Pearson linear correlation coefficient with significance level 0.05.

Results: For the healthy elderly, forefoot ground reaction force during isokinetic passive ankle movement had significant correlations with active ankle ROM ($N=11$ $r= .672$, $p=.024$) and TA muscle EMG activation level ($N=11$, $r=-.722$, $p=.012$). The stroke patient had significantly lower values in dynamic forefoot ground reaction force during a full range of passive dorsiflexion compared to healthy controls ($p<0.005$). Forefoot ground reaction force predicted TA muscle EMG activation during isokinetic passive ankle dorsiflexion ($p=0.008$).

Conclusion: These findings suggest that forefoot ground reaction force in AMT is associated with the TA muscle activation during isokinetic passive ankle dorsi-/plantarflexion in the elderly. AMT may be a useful assessment to understand neuromuscular characteristics in stroke patients. Future studies may examine gait characteristics and EMG activation patterns of ankle muscles during movements in frontal and sagittal planes.

T47: Mobile Phone-Based Ecological Momentary Assessment of Day-to-Day Paretic Hand Use following Stroke

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The extent of paretic hand use in the natural environment has been identified as a critical factor in recovery of function after stroke. Previous studies have used patient reports (e.g., Motor Activity Log, MAL), laboratory-based assessments (e.g., Actual Amount of Use Test, AAUT), or accelerometry to quantify stroke survivors' paretic hand use in the day-to-day environment. However, these measures either rely on retrospective memory that may be impaired following stroke (e.g., MAL), provide time- or context-limited samples (e.g., AAUT), or objective signals that may lack important subjective and contextual information (e.g., acceleration of hand movement).

To overcome these barriers, we employed a mobile-based prompt methodology – Ecological Momentary Assessment (EMA) – to capture individuals' daily hand use behavior. EMA minimizes retrospective memory biases and allows repeated, real-time, simultaneous measurements of behavioral (i.e., paretic hand use) and subjective/contextual variables (e.g., self-efficacy, affect, and social and functional contexts of paretic hand use). Here we report evidence pertaining to the feasibility of EMA in examining paretic hand use post-stroke in the real environment.

Twenty participants with right, dominant-side stroke (Fugl-Meyer score range, 21-66; stroke onset range, 0.7-14.8 years) received 6 EMA prompts/day during a 5-day community-monitoring period, and were encouraged to self-initiate prompts anytime. EMA prompts included questions for real-time hand use behavior [right/left/both hand(s) use, or neither-or-none hand use] and contextual social-cognitive variables.

On average, participants required 3.87 minutes to complete one prompt. An 85.8% response rate across participants was demonstrated (25.6 out of the 30 total prompts). Participants also self-triggered an additional 4.9 prompts during participation. Across a total of 608 valid completed prompts, participants showed a 9.7% proportion of right hand use, 22.0% of left hand use, 48.4% of both hands use, and 19.9% of no hand use. The most frequently reported activities were watching television, eating, and driving/riding. Participants were most commonly at home (indoors, 57.4%) or in a vehicle (9.5%) while responding. They were alone more than half of the time (52.6%) or with family (29.1%) if not alone. Interestingly, participants also reported significantly more right hand use in the morning (16.1%) than in the afternoon/evening (7.0%, $p = 0.049$) across 5 days.

The overall high response rate supports the feasibility of using EMA in the stroke population. The higher frequency of right hand use in the morning suggests a target for further investigation. Extended analyses with contextual social-cognitive information (e.g., activities) may help provide insight. In addition, analyses that link objective hand use measures (accelerometers) to EMA are planned to examine further the validity of EMA hand use responses. More robust evidence of the usefulness of EMA will also be provided by comparing EMA results with other assessments (e.g., MAL) with a larger sample size.

T49: Aerobic exercise may improve walking ability in people with Multiple Sclerosis. A Systematic review of evidence

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Introduction: Aerobic exercise is known to upregulate proteins in the blood that may promote brain repair among people with Multiple Sclerosis (MS). However, it is not clear if such aerobic exercises can improve walking ability in people with MS. The aim of this review is to determine the effectiveness of aerobic exercises in improving walking ability among people with MS.

Methods: Five literature databases (PubMed, Cochrane Library, Embase, Physiotherapy Evidence Database [PEDro], and SCOPUS) and reference lists of relevant reviews were searched. Randomized trials that investigated aerobic exercises for a period of at least 3 weeks or more, having outcomes in walking ability, were included. Two reviewers independently performed title, abstract and full-text review. From a total of 1783 articles identified, 8 manuscripts were included in this review.

Results: All trials that studied a gait-specific intervention (treadmill) reported improvements in walking ability. The treadmill training performed at 40 – 75% maximum heart rate for 8 weeks improved walking speed, distance and economy. The robot-assisted gait training performed by those with higher levels of disability using 20%-40% body-weight support on a maximum tolerated speed for 4 weeks, improved the timed up and go test outcomes.

Similarly, a trial that investigated leg cycling performed more frequently (thrice a week) at 30 to 60% work rate, improved walking speed and distance. However, a trial on aerobic cycling with lesser frequency (twice per week) did not show any changes in walking as well as neurotrophic factors in the blood. In total, 5 aerobic type interventions produced significant improvements in walking ability: treadmill training, repetitive endurance activities, progressive aerobic/strength combination training, robot-assisted treadmill and leg ergometer.

Conclusion: This systematic review suggests that aerobic exercises may improve walking ability in people with MS. However, further research is needed to corroborate this finding among those with higher disability.

Keywords: Multiple sclerosis; Aerobic exercise; Brain derived neurotrophic factor; Rehabilitation.

F1: Using metronome-timed bipedal hopping to estimate anticipatory feed-forward control in individuals with mild multiple sclerosis compared to control and elderly subjects

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Introduction: People with mild multiple sclerosis (MS) often report difficulty in balance and cognitive processing but display no measurable deficits on current clinical assessments. We examined whether hopping to a metronome beat has the potential to measure both physical and anticipatory control deficits in people with mild MS (Expanded Disease Severity Score≤3.5).

Methods: Participant with MS (n=13), matched controls (n=9) and elderly subjects (n=13) were recruited and tested for baseline cognition (Montreal Cognitive Assessment (MoCA)) and baseline motor performance (Timed 25 Foot Walk Test (T25FWT)). All participants performed two bipedal hopping tasks: one to the metronome beat of 40 beats/second and one to 60 beats/second.

Results: Elderly subjects hopped shorter distances than controls ($F=5.11$, $p=0.01$), with MS subjects falling in the middle. As hop length decreases, participants also tended to do worse on the T25FWT as these measures were significantly negatively correlated ($r=-0.452$, $p<0.01$). The MS group tended to become more delayed from the metronome beat over time whereas elderly subjects tended to hop closer to the beat over time ($F=4.52$, $p=0.02$). Additionally, this measure of adapting to the metronome beat over time was correlated with overall MoCA score ($r=0.38$, $p=0.03$).

Conclusions: These findings suggest that our new type of hop test may be able to detect both physical ability and feed-forward anticipatory control impairments in people with mild MS. Our results correlate to current gold standard clinical assessments (MoCA and T25FWT), indicating accuracy in these measurements. Measuring these deficits is important for early detection and rehabilitation of physical and neural processing in MS.

F2: Leveraging energetics of walking to change gait symmetry

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Humans prefer to move in ways that minimize energy cost. This is particularly apparent during walking, where economy is a key determinant of many gait features (e.g., speed, step length, step width, cadence). Here we were interested in leveraging energetics to change gait symmetry, a gait feature with clinical relevance for several neurologic populations.

We collected kinematic and oxygen consumption data from young adults (n=44) as they walked on a treadmill. In Experiment 1, we tested participants on two separate days. On day 1, the participants walked at five different speeds - preferred, 0.5, 1.0, 1.5, and 2.0 m/s - for five minutes each. They then walked at their preferred speed while seeing continuous feedback of their ankle locations and a series of vertically-arranged targets. They used the feedback and targets to perform five different walking patterns - no limp, small left or right limp, large left or right limp - for five minutes each. We confirmed that energy cost was lowest near the preferred speed and increased with limping.

On day 2, we activated a controller that changed the treadmill speed depending on how the participants walked on the treadmill (i.e., each day 1 pattern was paired with a different day 1 speed). We designed the pairings such that limping was now less costly than symmetric walking, as the limps were paired with speeds closer to preferred while symmetric walking caused the treadmill to move at 0.5 m/s. Participants performed each pairing for five minutes, allowing us to obtain the energy cost of each. They then freely explored the pairings for ten minutes to get a "feel" for each one. Finally, with the controller still on, we asked them to walk however they felt most comfortable for five minutes ("test period"). We found that 63% of participants walked with a limp at a non-preferred speed.

Because we constrained the test period by time and not distance in Experiment 1, we considered that some participants may have prioritized total energy expenditure while others prioritized energy cost. In Experiment 2, the protocol was identical to day 2 from Experiment 1 except participants walked for one kilometer instead of five minutes during the test period. We displayed the distance traveled in real time during the exploration and test periods. We found that 88% of participants walked with a limp at a non-preferred speed while walking the kilometer.

Energetics plays an important role in determining how we walk. Here we find that we can leverage the energy cost of walking to change gait symmetry. Specifically, we show that the healthy nervous system will readily change gait symmetry to improve walking economy.

F3: Modulating cortical plasticity as a means to promote upper limb recovery in incomplete tetraplegia

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Current published work suggests that a minimum of 9 months of rehabilitation is required to elicit significant improvements in upper limb function following incomplete spinal cord injury (iSCI). With over 12,500 new cases and a prevalence of 337,000 in the U.S. alone, however, such extensive rehabilitation programs are impractical. In the present study, we tested the hypothesis that the brain and its residual descending pathways represent the most spared, and hence ideal, innovative targets for maximizing and accelerating upper limb motor recovery in iSCI. Specifically, a key reason the effectiveness of rehabilitation remains weak is due to detrimental consequences that affect surviving neural substrates after the injury. Representations of the stronger muscles in the motor cortex exaggerate and over take weaker muscles that are innervated below the injury. Residual descending pathways to the weaker muscles also become less excitable. Based on our prior work in stroke, we hypothesized that transcranial direct current stimulation (tDCS) may be an ideal adjunct to help restore representations of weaker muscles and boost the excitability of their residual pathways to ultimately maximize functional outcomes following rehabilitation. To test our hypothesis, eight individuals with chronic iSCI received either upper limb rehabilitation with tDCS (2 mA anodal) to motor cortical representations of weak muscles or rehabilitation alone. Representational plasticity was measured using TMS before and after treatment, while diffusion tensor magnetic resonance imaging (DTI) quantified residual integrity of descending tracts. Functional recovery and muscle strength was assessed before and after treatment and at three-month follow-up. We found that subjects who received tDCS during rehabilitation demonstrated significant increases in the cortical representation of their weaker muscle, where its excitability increased by 60% ($p<0.05$). We also found that subjects who received tDCS with rehabilitation had a significant reduction in the representation of the stronger muscle (70%). Plasticity changes for both groups were associated with gains in motor function, with the tDCS group demonstrating a slight advantage that was sustained for three months following treatment. In addition, level of recovery was related to residual integrity of descending tracts, wherein subjects that demonstrated the most recovery had greatest tract sparing following their iSCI ($r=0.97$; $p<0.0001$). Our results suggest that long-term pairing of tDCS with rehabilitation could result in significant functional improvements by facilitating plasticity of weaker cortical representations. Further, descending tract integrity, as measured with DTI, may serve as a valuable prognostic marker of impairment and functional recovery potential.

F4: Suppressing contralesional primary motor cortex versus facilitation contralesional dorsal premotor cortex in stroke: deriving and testing a model to tailor brain stimulation

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Repetitive transcranial magnetic stimulation (rTMS) has been used to facilitate excitability of the ipsilesional primary motor cortex (iM1). A common approach involves suppressing excitability of the 'inhibitory' contralesional cortices. However, this standard approach ignores that iM1 cannot experience any gains in excitability or contribute to the plastic potential in recovery of the paretic upper limb when its pathways are extensively damaged. In such cases, contralesional areas especially the contralesional dorsal premotor cortex (cPMd) instead can contribute to recovery. Stimulating iM1 in patients with mild and stimulating cPMd in patients with greater damage will ensure that recovery is enhanced across all ranges of damage and disability. However, a cut-off which categorizes patients has never been identified. The purpose of our study was to address this gap so patients could be assigned to tailored stimulation of standard iM1 and cPMd. Fifteen patients with chronic stroke (age: 61.53 ± 2.22) participated in a randomized, controlled, repeated measures crossover study, where they received single sessions of standard stimulation of iM1 (by suppression of contralesional cortices) and stimulation of cPMd, besides sham. We measured improvements in reaching time (RT) at the paretic upper limb. Additionally, we measured changes in neurophysiology, viz. corticospinal excitability of iM1 (recruitment curve) and inhibition of iM1 by contralesional cortices. We studied how changes in RT and neurophysiology varied with baseline impairment (Upper Extremity Fugl MeyerPROXIMAL or UEFMPROXIMAL, max= 36), and structural and physiologic damage to pathways measured using Fractional Anisotropy or FA (Diffusion Tensor Imaging) and active motor threshold or AMT with TMS respectively. We have found that improvements resulting from stimulating iM1 decrease with the greater degree of damage and impairment ($r= -0.60$, $p = 0.019$), whereas improvements with stimulating cPMd increase ($r= 0.90$, $p = 0.001$). Since improvements with stimulating iM1 and cPMd vary in opposite ways, regression curves for both intersect to yield cut-off level of baseline damage and impairment. Classification and Regression Tree analysis identifies patients with UEFMPROXIMAL > 26-28 and FA > 0.5 as candidates for standard stimulation of iM1 and patients with UEFMPROXIMAL < 28 as candidates for stimulation of cPMd. Candidates for iM1 show gains in corticospinal excitability with stimulation of iM1 ($r= -0.64$, $p= 0.05$) while candidates for cPMd experience reduced inhibition from contralesional cortices after stimulation of cPMd ($r= -0.70$, $p= 0.0001$). Our findings provide a unique opportunity to enhance benefits of stimulation in patients with severe damage, who otherwise fail to improve with standard approaches. In addition, we are the first group to validate the recent bimodal hypothesis of plasticity that believes that iM1

F5: Does Transcranial Direct Current Stimulation Plus Concurrent Activity Lessen Dual Task Cost In People With Parkinson's Disease?

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Background & Objective: Progressive deterioration of cognitive and motor function is characteristic in Parkinson's disease (PD). 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) may have therapeutic potential as it has demonstrated isolated facilitation of motor and cognitive processing in people with PD. Our purpose was to identify if application of bilateral brain hemisphere tDCS with concurrent activity improved dual task gait in people with PD.

Design: Participants received four sessions of tDCS protocol ($tDCS_{sitting}$, $tDCS_{aerobic,}$ $tDCS_{Wii,}$ $tDCS_{sham}$) during medication "ON" times each separated by 7 days. tDCS protocols were randomized and sham 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 seven people with PD age 44-77 years.

Interventions: Three 20-minute session of bilateral tDCS (dorsolateral prefrontal cortex; left = anode, right = cathode) at 2mA and one sham session. tDCS protocols were sitting alone, playing Wii golf, and pedaling a recumbent bicycle at moderate intensity.

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)]. Immediately following each of the four tDCS conditions, 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=43.71(range=20-70), RBANS x=80.71 (9%ile)] gait velocity dual task cost for TUG_{motor} was 12.54% ($tDCS_{sitting}$), 27.26% ($tDCS_{aerobic}$), 16.66% ($tDCS_{Wii)}$), 16.46% ($tDCS_{sham}$); for $TUG_{cognitive}$ was 26.25% ($tDCS_{sitting}$), 35.92% ($tDCS_{aerobic}$), 37% ($tDCS_{Wii}$), -25.23% ($tDCS_{sham}$). Cognitive dual task cost for $TUG_{cognitive}$ was 57.62% ($tDCS_{sitting}$), -12.04% ($tDCS_{aerobic}$), -26.52% ($tDCS_{Wii}$), 25.86% ($tDCS_{sham}$). PDQ-39 following each session, where a lower score reflects a greater quality of life, was 20.23 ($tDCS_{sitting}$), 17.21 ($tDCS_{aerobic}$), 20.17 ($tDCS_{Wii}$), and 19.98 ($tDCS_{sham}$).

Conclusions: Our bilateral brain hemisphere tDCS did not lessen dual task cost when paired with aerobic and Wii golf activities in participants with PD. Fatigue may have limited performance on single and dual task gait following the concurrent aerobic and Wii activities. However, bilateral brain hemisphere tDCS when paired with a concurrent activity may deliver a gait task specific benefit, rather than overall gait benefits. Further investigation of our bilateral brain hemisphere tDCS approach on dual task gait in people with PD with larger sample size appears warranted.

F6: Effects of Introducing Variability on Bimanual Coordination in Individuals with and without Stroke

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Motor impairments inthe upper extremity often result in compensation between the affected and unaffected arms, which has led to controversy over whether bimanual training is helpful for rehabilitaiton. There is therefore a greater need to understand the underlying mechanisms of the coordination between the two arms after stroke, and how flexible this coordination is.

The purpose of the current study was to examine how flexible the coordination between the two arms is after stroke. Using a virtual task, we "artificially" introduced variability in either the affected or the unaffected arm during a bimanual reaching task in stroke survivors. We examined whether the coordination between the arms stayed fixed across conditions, or was flexible (i.e. changed according to the variability).

Methods: Participants were divided into two groups - (i) adults with no history of stroke or other motor impairments, and (ii) adults with stroke who had mild to moderate arm impairment (but sufficient arm function to perform reaching movements on a table with both the affected and unaffected arms). Participants were seated at a table and we used reflective markers on the head, trunk, and bilaterally on the shoulder, elbow, wrist and MCP joints to record 3D positions using a motion capture system. The movements were fed in real-time to a computer and the goal of the participants was to control a cursor on a screen which was computed as the average position of the two hands. We added variability in some conditions by introducing a variable rotation angle either on the unaffected or the affected arm. The order of which hand had variability added was counterbalanced across participants.

Result: Data collection is still under progress but preliminary results on unimpaired controls show that participants indeed reorganized their movement pattern to accomodate for the variability. Specifically, the reaching direction variability was lower in the "variable arm", which was compensated for by the "less variable" arm. We will examine how stroke participants behave in this task and whether this paradigm can potentially provide a way to enhance control of the affected arm.

F7: Comfortable walking speed outcomes associated with "hands-free" vs "skills-based" BWS training poststroke

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Objective: To compare walking and balance outcomes of two task-oriented, body-weight-supported (BWS) walking training approaches, hands-free (HF) versus skill-based (SB) walking, during a six-week regimen that targeted comparable heart-rate zones for participants with poststroke hemiparesis.
Design: Single-blinded, randomized controlled clinical trial.
Setting: Clinical research facility.
Participants: Twenty-eight participants with chronic poststroke hemiparesis, who were able to ambulate with or without assistance, but who had slow walking speeds less than 1.0 m/s at baseline.
Interventions: Participants were randomly allocated to HF (n=13) or SB (n=15) training. Both interventions comprised eighteen sessions of thirty-minute walking training over six weeks. Walking training was performed on a self-driven, robotically controlled treadmill system (KineAssist), with different levels of BWS. The HF group walked without the use of assistive devices or handrails, while the SB group performed nine different skills (i.e., hurdles, long or narrow steps, foam shoes, speeding up/slowing down, perturbations, head turns, variable speed changes, and backward walking). All participants targeted 60 to 80% heart rate based on the Karvonen formula.
Ma**in measures:** The primary outcome was comfortable walking speed (CWS), measured by an overground, ten-meter walk test. Secondary outcomes included overground fast walking speed, six-minute walk distance, and scores on the Activity Specific Balance Scale, Stroke Impact Mobility Scale, Geriatric Depression Scale, Berg Balance Scale, and Dynamic Gait Index-4.
Results: Collectively, participants significantly increased CWS from 0.57 ± 0.06 m/s at baseline to 0.68 ± 0.07 m/s post intervention t(1,27)=-4.95; p<0.001. HF participants increased from 0.59 ± 0.10 m/s to 0.70 ± 0.11 m/s (t(1,12)=-3.41; p=0.005), and SB participants increased from 0.56 ± 0.08 m/s to 0.66 ± 0.09 m/s (t(1,14)=-3.50; p=0.004). For both groups, participants classified as "moderate" (i.e., baseline CWS >0.5m/s) achieved greater CWS improvements. Moderate HF participants increased CWS from 0.90 ± 0.05 m/s to 1.03 ± 0.04 m/s (t(1,6)=-5.56; p=0.001), and moderate SB participants increased from 0.87 ± 0.05 m/s to 0.99 ± 0.03 m/s (t(1,6)=-2.70; p=0.04). In comparison, participants classified as "severe" (i.e., baseline CWS <0.5m/s) did not exhibit significant increases in CWS. Severe HF participants increased CWS from 0.22 ± 0.04 m/s to 0.32 ± 0.09 m/s (t(1,5)=-1.42; p=0.22), and severe SB participants increased from 0.29 ± 0.03 m/s to 0.36 ± 0.04 m/s (t(1,7)=-2.2; p=0.06). After training, fewer participants walked slower than 0.4 m/s (n=14 baseline vs. n=8 post), more walked between 0.4 and 0.8 m/s (n=4 vs. n=6), and more walked faster than 0.8 m/s (n=10 vs. n=14). There were no severe adverse events in either arm of the trial.
Conclusion: Both HF and SB training improved CWS outcomes, with similar improvements between groups for individuals with moderate speed deficits at baseline. BWS can be effectively applied during challenging walking conditions to improve CWS outcomes.

F8: Feasibility of Combined Brain and Hand Stimulation in Moderate to Severe Individuals with Chronic Stroke

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Introduction: Among the 795,000 individuals who sustain a stroke annually in the United States, 65% continue to experience severe impairments in one upper extremity six months after stroke, limiting their ability to perform daily tasks. Currently there are no effective interventions to improve hand function in moderate-to-severe chronic stroke. Using the principles of neuroplasticity, we developed a novel intervention, which combines non-invasive brain stimulation with functional electrical hand stimulation for individuals with moderate-to-severe impairments. The purpose of this study was to investigate the feasibility of this intervention in individuals with chronic stroke.

Methods: We investigated the feasibility with three participants. All participants received a total of 18 treatment sessions three times a week for 6 weeks. Each treatment session lasted for 30 minutes where participants practiced grasping and releasing meaningful objects (15 minutes each) with the functional electrical stimulation of the weak hand. Simultaneously, we delivered the non-invasive brain stimulation via weak random noise currents to stimulate the damaged motor cortex. We assessed the feasibility using indicators related to both participants and therapists. For participants, we examined the number of participants retained, the number and duration of treatment sessions completed, type of adverse effects, participants' comprehension of information, participants' engagement in the treatment, and participants' acceptability of treatment. For therapists, we examined treatment fidelity (adherence and competence in execution to treatment) by reviewing a random 20% of sessions using a validated fidelity checklist. We also examined the impairment in upper extremity (Fugl Meyer Upper Extremity Subscale) and amount of hand use in daily tasks [Motor Activity Log (MAL))] before and after treatment. We computed descriptive statistics for the analysis.

Results: The mean age and chronicity of the participants was 52.6 years (range: 47-59) and 2.5 years (range: 1-5). We achieved 100% feasibility on all participant related indicators. All participants reported minimal adverse effects (mild tingling in head and fatigue in the affected hand). The two trained therapists adhered to 95% of manualized procedures and demonstrated acceptable or exceptional competence for 100% of the completed procedures. The Upper Extremtiy Fugl Meyer scores showed at least a 5 point change pre and post treatment = 31 (pre: range: 22-39) to 35 (post: range: 27-43); MAL amount of habnd use scores showed at least a 1 point change = 2.12 (pre: range: .87-2.9) to 3.4 (post: range: 2.83-4).

Conclusion: It is feasible and acceptable to administer combined non-invasive brain and hand stimulation in moderate-to-severe clients with chronic stroke.

F9: Virtual Reality Treatment for Phantom Limb Pain

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Phantom limb sensations occur in up to 90% of amputees, many of whom also experience persistent pain in their phantom limb (PLP). Current treatments do not provide relief for a majority of people with PLP. This study provides preliminary data on reduction of PLP in lower-limb amputees resulting from training with low cost virtual reality (VR) games (e.g., chess). During game play, the patient views a real-time rendering of two intact legs in a head-mounted display. Virtual movements of the missing extremity are controlled by feedback from inertial measurement units mounted on the residual limb. Two patients with unilateral below-the-knee leg amputation underwent multiple sessions of the VR treatment. Both participants rated their level of pain to be reduced after each VR session, and this beneficial effect persisted several weeks after testing. Although preliminary, these data suggest that our VR intervention may be an effective and low cost treatment of PLP in amputees.

F10: Referent control and motor equivalence is disrupted in patients with stroke when reaching from standing

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Background
In motor tasks such as reaching from standing, the nervous system has to organize the action of a large number of body segments and joints in order to maintain reaching accuracy. Reaching from standing can be accomplished by different combinations of joint movements permitting the system to adapt to unexpected situations, a process known as motor equivalence. We propose that the process underlying motor equivalence is based on specification of a referent body configuration defined as the body posture at which muscles begin to be activated or deactivated. Movement emerges due to minimization of the difference between the actual configuration which deviates from the referent one due to inertia of different body segments and environmental forces. This explanation has been used to understand whole body reaching behavior in healthy subjects (Tomita et al., subm). Due to damage to descending systems and changes in processing of afferent information after stroke, this process may be disrupted, leading to postural instability and lack of motor adaptability.

Methods
Individuals with mild/moderate stroke and healthy controls reached from standing toward a remembered target placed beyond the reach of the arm (130% arm length). To accomplish the reach, individuals had to combine arm motion with hip flexion (Free-Hip Trials). In 30% of randomly chosen trials, hip flexion was unexpectedly blocked by an electromagnet which forced the subject to take a step forward to prevent falling while reaching (Blocked-Hip Trials). For comparison, reaching was repeated when the subject took an intentional step (Intentional-Step Trials). Upper limb endpoint trajectories, movement accuracy and upper/ lower limb and trunk kinematics were recorded with an Optotrak (100 Hz) system.

Results
The direction and shape of endpoint trajectories were similar between Blocked-Hip and Free-Hip trials in control subjects and subjects with mild stroke. Taking a step (Intentional-Step Trials) resulted in additional trunk displacement which did not affect movement accuracy. Endpoint trajectory shape and accuracy were similar between conditions due to motor equivalent adaptations in elbow-shoulder interjoint coordination. In contrast, reaching trajectories in all conditions were more variable in subjects with moderate stroke endpoint trajectories differed between Blocked-Hip and Free-Hip trials

Conclusion
The ability to appropriately adapt interjoint coordination to changing task conditions was impaired in individuals with moderate stroke, which may be explained by deficits in the specification of the referent body configuration for control of reaching. This deficit in higher order motor control skills, which may restrict motor recovery, is not routinely identified in commonly used clinical scales.

F11: Hand position sense is abnormal in children with developmental coordination disorder: Introducing a new method to measure proprioception

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It has long been suspected that proprioceptive abnormalities underlie the motor problems in children with developmental coordination disorder (DCD). However, current empirical evidence of a proprioceptive dysfunction in DCD is unequivocal, which at least partially, is owned to the fact that existing clinical exams and tests lack measurement sensitivity or are often too cumbersome to conduct in clinical or school settings. Thus, the introduction of a simple, yet sensitive test to assess proprioceptive function in pediatric populations would be welcome and could verify the claim that a proprioceptive deficit underlies DCD.
Purpose: Using a novel wrist manipulandum, the present study assessed wrist position sense acuity in children with DCD adopting a psychometric method of threshold testing.
Methods: Ten children with DCD and twenty typically developing children aged 10-11 years old participated. All children were screened using Movement Assessment Battery for Children (MABC-2) to assign them into two groups: DCD and typically developing children (TD). The wrist device allows to generate 140 different wrist positions from 0°-70° of wrist flexion in 0.5° increments). All children wore googles to block vision. During the testing, their dominant hand rested on the manipulandum lever and was passively moved to two different positions (a reference and a comparison position). Children had to judge two positions and to indicate which position is farther away from the staring position (i.e. more flexed). An adaptive algorithm (psi-marginal) was used to generate the subsequent stimulus pair. A just-noticeable-difference threshold (JND) threshold was obtained by fitting a logistic Weibull function to the individual verbal response data. All children finished 30 discrimination trials, which took about 10-15 minutes per child.
Results: Children with DCD had a significantly enhanced JND joint position sense threshold when compared to typically developing children [$t(28) = -2.62$, $p = .014$)]. Mean JND threshold of the DCD group was increased by 156% with respect the typically developing children [DCD group: 3.94° (SD: 1.40°); TD group: 2.52° (SD: 1.38°).
Conclusion: This study provided objective data on proprioceptive function indicating that children with DCD children show elevated position sense thresholds. A larger sample will be necessary to establish the range of proprioceptive dysfunction in DCD. These psychophysical data could then guide future research to map the differences in cortical somatosensory networks with the degree of proprioceptive abnormality in children with DCD. Finally, the test was easily comprehensible for children and simple to administer. It can potentially be applied to a wide range of pediatric conditions associated with decreased proprioceptive function.

F12: Remote Monitoring of Upper Extremity Movement in Children with Stroke Using Smart Phones and Gaming.

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Background and Objective: It has been demonstrated that development of effective rehabilitation strategies will substantially improve functional recovery in patients with stroke, and that regular assessment of motor function is critical for implementing correct rehabilitation intervention. Unfortunately, access to specialized care is extremely limited, particularly for children from underprivileged background or patients living in rural areas due to unavailability of pediatric care, financial difficulties, and problems with transportation. Therefore, many stroke victims receive less-than-optimal care, and do not achieve their full functional potential. The objective of this study is 1) to develop a user-friendly smartphone application to easily obtain user-data related to wrist function; 2) to demonstrate that if is feasible to adopt biometrics solutions combining body recognition strategies with available low-cost technology to monitor upper extremity motor function after stroke.

Methods: A custom application was developed for the Android platform and deployed in a Samsung GalaxyS3 smartphone for collection of user's movements. This phone is equipped with multiple sensors, including motion and position sensors. The motion can be gauged using the accelerometer and gyroscope sensors (hardware), as well as gravity, linear acceleration and rotation vector sensors (software). Data was collected from 8 patients and 8 healthy controls (age 15-52) during performance of standardized wrist movement including flexion/extension, pronation/supination, and ulnar and radial deviation.

Results: Visual inspection of the sensor data suggests the possibility of distinguishing movements of healthy subjects from that of stroke patients. A preliminary attempt was made to automatically classify the data into healthy and impaired subjects using machine learning schemes. An accuracy of 91.7% could be achieved on this small dataset.

Conclusion: Our preliminary results demonstrated that it is possible to distinguish healthy movements from impaired wrist movements based on smart-phone manipulation data. Further work is needed to develop strategies for quantification of multiple levels of motor impairment in stroke patients. This work carries potential for the remote monitoring of motor function following stroke and for assessing treatment efficacy thereby leading to more appropriate clinical decisions for patients with poor access to specialized care. Additionally, home-based monitoring will directly engage patients, provide immediate feedback, and help develop a culture of shared knowledge and self-confidence in the management of chronic condition.

F13: Impaired sequence specific learning with the paretic arm after stroke

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Motor sequence learning is important for neurological recovery and is the basis for rehabilitation strategies such as task specific training. Tasks that assess motor sequence learning often require dexterous finger movements, which are difficult or impossible for stroke survivors with upper limb impairment. This makes it difficult to draw conclusions about the impact of stroke on learning motor sequences. Using an explicit motor sequence learning task requiring gross arm movements we aimed to determine whether stroke survivors with upper limb impairment would be able to learn a sequence of movements as effectively as healthy age-matched participants. In the first study, 10 chronic stroke survivors (10-138 months duration, mean age 64 years, range 39-80) with mild-moderate upper limb impairment (Fugl-Meyer upper limb score ≤ 60) and 10 healthy age-matched controls (mean 66 years, range 50-85) participated. They used their paretic (stroke) or non-dominant (controls) hand to direct a computer mouse to illuminated targets on a monitor in a repeating sequence. A sequence of 10 movements was repeated 25 times followed by a random sequence. Both stroke survivors and controls reduced their time to react to target illumination (onset time; OT) across the repeating blocks ($p < 0.05$) with no change in speed of movement or accuracy ($p > 0.1$). We quantified learning as the difference between the OT at the end of training and the OT in the random sequence. This was less in the stroke group compared with controls (Mann Whitney U test: $p = 0.015$), indicating that chronic stroke survivors show impaired sequence specific learning. In the second study, a subsample from a larger study was selected to determine whether impairment in sequence specific learning would also be evident within six months of stroke, and whether learning could be improved with non-invasive brain stimulation. Nine stroke survivors (mean 4 months post-stroke, 36-74 years of age) and nine age-matched healthy controls (34-74 years of age) performed the same motor sequence learning task twice, at least one week apart. Anodal transcranial direct current stimulation (tDCS; 20 min, 1 mA) or sham stimulation was delivered to the primary motor cortex in a single-blind crossover design. Stroke survivors again demonstrated impaired sequence specific learning compared with healthy controls during sham stimulation (Mann Whitney U test: $p < 0.001$) and this was not improved with anodal tDCS (Wilcoxon signed rank test: $p > 0.3$). Overall, these experiments show that stroke survivors can learn a movement sequence with the paretic arm, but demonstrate impairments in sequence specific learning in comparison with healthy controls. These findings have implications for re-learning of movements through rehabilitation after stroke.

F14: Adjacent Motor Cortical Areas Have Distinct Brain Functional Connectivity

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Background
Postural control studies suggest that primary motor area (M1) is responsible for volitional movement execution while supplementary motor area (SMA) plays a role in postural preparation. Support for the role of SMA in postural control would be provided by determining functional connectivity and establishing greater connection of SMA to critical postural control areas compared to M1. Both M1 and SMA have direct projections to the spinal cord, thus muscle representational maps can be obtained using transcranial magnetic stimulation (TMS). However, motor representational maps do not identify what brain areas are connected to M1 and SMA. Resting-state functional magnetic resonance imaging (rs-fMRI) can be used to identify muscle-specific neural circuitries. This study will compare whole-brain functional connectivity (FC) of SMA and M1 representational areas of external oblique (EO) to gain insight into the differential function of SMA and M1 in the control of this muscle.

Purpose
Determine the location of EO cortical representation and explore resting state (rs) FC in SMA and M1 among healthy adults.

Methods
13 adults participated. TMS mapping of M1 and SMA was conducted. MEP amplitudes for EO determined the Center of Gravity (CoG) in both M1 and SMA. The MNI coordinates of EO CoG in SMA and M1 were used to explore FC of these areas utilizing rs-fMRI.

Results
MEPs were elicited consistently in M1 and SMA. MNI coordinates for EO CoG were determined for M1 and SMA. FC analysis demonstrate that anterior cingulate, basal ganglia and cerebellum are more connected to SMA; Prefrontal, precuneus, and parietal cortex are more connected to M1.

Conclusion
While EO is represented in both SMA and M1, these representations are not functionally equivalent in their interaction with the rest of the brain. Therefore, SMA and M1 may play distinct roles in the control of this postural muscle. Greater connectivity of SMA to basal ganglia and cerebellum compared to M1 can support the distinct role of SMA in postural control.

Funding from the Neuroplasticity and Imaging Laboratory in the Division of Biokinesiology and Physical Therapy at USC.

F15: Sensory and motor system predictors of treatment gains after robotic retraining of finger movements post-stroke

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Particularly for the fingers, motor and sensory function is inextricably linked since the hand functions as a haptically-based organ. This study characterized the role of the motor system and somatosensory system during robot-assisted finger movement training. Measures of behavioral impairment, brain injury, and cortical function of the sensory and motor systems were acquired at baseline to understand predictors of treatment gains.
At baseline, patients with chronic stroke completed clinical motor assessments and a robotic assessment of proprioception with their stroke-affected hand. Patients also underwent MRI and fMRI scanning, wherein they alternated rest with affected-side finger movements similar to those made during robotic therapy. Next, subjects received therapy 3 hr/wk for 3 weeks using FINGER (Finger Individuating Grasp Exercise Robot), with which subjects moved their paretic index and middle fingers to play a musical game similar to GuitarHero. FINGER provided assistance as needed to facilitate completion of grasping movements, which increased sensory feedback without altering voluntary motor output.
Thirty subjects (mean age 58 yr; baseline Fugl-Meyer 46 out of 66; 37 mo post-stroke) completed the study. Significant gains were found in the primary outcome measure, change in Box & Blocks (B&B) score (23 to 25.5, $p<0.0001$). The most significant predictors of therapy gains were: proprioception error ($r=-0.60$, $p=0.0008$), total sensory system anatomical injury ($r=-0.45$, $p=0.03$), and interhemispheric balance of cortical activation toward the ipsilesional hemisphere in the primary sensory cortex ($r=0.60$, $p=0.005$). When these variables were incorporated into a multivariate model, the behavioral and cortical function measures survived and the resulting model explained 56% of variance in treatment-induced motor gains. Had this model been applied to this patient sample at baseline, and only the top 30% of potential gainers enrolled, the average predicted increase in B&B score would be 7 blocks.
These results indicate that sensory factors are key in regaining finger motor function after rehabilitation therapy. Sensory assessments were more significant predictors of treatment gains than motor system counterparts. This may reflect the robotic therapy used here, which is based on the hypothesis that increased sensory input coincident with voluntary motor output drives plasticity. Notably, the robotic assessment of proprioception at baseline was a better predictor of motor gains than a standardized clinical assessment of position sense, suggesting that conventional clinical sensory assessments lack the resolution needed for predictive power. Additionally, an assessment of total sensory system injury was a better predictor of motor gains than any individual anatomical injury measurement, suggesting the sensory system is a distributed network.
In full, this study provides evidence that sensory processing is a key element in recovering motor function after stroke, and assessments of the sensory system can be used to determine potential patient benefits from robotic therapy.

F16: The role of neural networks for attention and arousal in stroke-induced spatial neglect and delirium

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Delirium is an acute reduction in attention and cognitive function. It negatively affects functional outcomes and increases mortality risk. After right-brain stroke, the risk for developing delirium can be as high as 50%. A further complication is that up to 50% of right stroke patients also experience spatial neglect, a decreased ability to notice, orient to, or act upon stimuli in the contralesional hemispace. Spatial neglect has been associated with dysfunction of the right-dominant ventral attention network with a subsequent disruption of a bilateral dorsal attention network. We hypothesize that delirium may result from an acute dysfunction of these cortical attention networks and a concurrent disruption of the ascending subcortical inputs that regulate arousal. Based on the strong prediction that the high co-morbidity of both spatial neglect and delirium with right-hemisphere stroke lesions results from a disruption of common right-brain mechanisms we hypothesized that (1) positive symptoms for stroke-induced delirium would be associated with positive symptoms for spatial neglect and that, (2) compared to spatial neglect patients, lesions in patients with delirium would include subcortical structures implicated in consciousness and arousal. We also expected that both disorders will affect frontal and/or parietal components of the cortical attention networks. To examine the hypothesis in the present study, we recruited 14 right-hemisphere stroke survivors (8 females, 9 with spatial neglect, mean age=57, SD = 18.0) from an inpatient rehabilitation facility. The participants were assessed for delirium with the Confusion Assessment Method (CAM, Inouye et al., 1990; 2014), which provides a binary delirium diagnosis as well as an assignment of a severity score (score range = 0-19; higher scores = more symptoms and thus greater severity). We assessed spatial neglect using the Behavioral Inattention Test (BIT; Halligan, Cockburn, & Wilson, 1991; score range = 0 - 146; higher scores = better performance). Participants' cognitive function was evaluated using the Florida Mental Status Exam (FMSE; Doty et al., 1990), an assessment of language, memory, attention and orientation. We found that better performance on the BIT was associated with fewer delirium symptoms (Spearman rho = - .64, $p < .05$). CAM was also significantly associated with the star cancellation subset of the BIT (Spearman rho = -.72, $p = .005$), and the orientation subset of the FMSE (Spearman rho = -.81, $p = .001$). In line with our hypotheses, brain lesions of patients who met CAM criteria for delirium (n=3) affected subcortical structures linked to arousal, such as corpus callosum and ventral striatum, and cortical locations in the inferior and superior frontal areas. Spatial neglect patients without delirium (n=10, 1 excluded) had superior temporal and posterior parietal stroke lesions, and lesions that involved white matter, consistent with prior lesion-deficit studies.

F17: The Proportion of Critical Area Damaged as a Predictor of Behavioral Outcome in Chronic Aphasia

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One-third of stroke survivors suffer from aphasia, or a loss of language ability, and the variability in recovery of language function seen in people with aphasia is not clearly understood. Several different post-stroke factors, particularly lesion size, time since stroke, and lesion location, have been implicated in behavioral recovery in stroke survivors, but current models of recovery provide poor predictive power. In particular, lesion location relative to critical areas has been poorly accounted for. In this study we developed an approach for estimating the degree to which critical areas for various language functions are damaged in each individual in order to better predict behavioral outcomes in chronic aphasia.

Using a leave-one-out design, we used multivariate Support Vector Regression Lesion-Symptom Mapping (SVR-LSM) to identify critical areas for different aspects of language function. SVR-LSM analyses were conducted for three behavioral measures: Auditory-Verbal Comprehension (AVC), Naming and Word Finding (NWF), and Spontaneous Speech (SS) from the Western Aphasia Battery. SVR-LSM results produce a beta weight for each voxel, indicating the degree to which a lesion in that voxel was associated with either a deficit (negative beta weights) or preserved ability (positive beta weights). Beta maps were thresholded at negative 1, 5, 10 and 15 percent and positive 1, 5, 10, and 15 percent of most critical voxels. Then, each participant's lesion was compared to the thresholded SVR-LSM map, and the Proportion of that Critical Area Damaged (PCAD) was quantified for each individual.

Next, PCADs were entered into a hierarchical multiple regression with behavioral scores as the dependent variable. In the baseline model, we included predictor variables that have been shown to predict behavioral outcomes in stroke recovery: lesion size, time-since-stroke, age, gender, education, and handedness. Then, PCADs based on both the positive and negative beta weights were added, to assess whether PCAD improved predictive power.

We found that PCADs calculated on the top and bottom 15% of the voxels accounted for more variance than PCADs calculated at other thresholds. Positive and negative 15% PCAD significantly improved the model fit for predicting AVC (R2= .27 without PCAD to .62 with PCAD) and NWF (R2= .40 to .46) PCAD did not significantly improve our model for predicting SS (R2=0.47 to R2= .51).

Our findings confirm that lesion location plays a significant role in the recovery of specific language abilities following left hemisphere stroke. The PCAD measure developed here will be useful for modeling deficits and understanding how other factors, such as neural plasticity, contribute to recovery. Further research will be needed to determine if applying the PCAD approach to acute stroke images may help with prognosis of outcomes in the chronic period.

F18: Dorsal and ventral premotor areas produce distinct modulation on primary motor cortex outputs

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Stroke often causes damage to the primary motor cortex (M1), leading to severe motor deficits in the upper limb. Through their numerous connections with M1, premotor areas of both hemispheres are thought to provide substrates for motor recovery after stroke. However, the functional connectivity between M1 and premotor areas is still poorly understood in healthy subjects. This information is important in order to better comprehend the changes occurring in intra and interhemispheric interactions after stroke. In *Cebus apella*, we investigated the modulatory effects of contralateral dorsal and ventral premotor cortex (cPMd, cPMv) on M1 outputs using paired pulse protocols and compared them to those of ipsilateral PMd and PMv (iPMd, iPMv). A bilateral craniotomy exposed cPMd, cPMv, iPMd, iPMv and M1 and the hand representation of each area was identified. An electrode was placed in cPMd, cPMv, iPMd or iPMv to deliver a sub-threshold conditioning stimulus (C). A second electrode was placed in M1 to deliver a supra-threshold stimulus (T). The C and T stimuli were separated by 6 inter-stimulus intervals (ISIs; range: 0-20ms). To quantify the conditioning effects, motor evoked potentials (MEPs) were recorded in 8 forelimb and intrinsic hand muscles from 4 monkeys (cPMd-M1: n=41, cPMv-M1: n=44, iPMd-M1: n=41, iPMv-M1: n=42). The conditioning of cPMd exerted more facilitation (62%) than inhibition (38%) on the outputs of M1. The prevalence of facilitatory effects was similar across tested ISIs while inhibitory effects were most prevalent with intermediate ISIs (5-10ms). Conversely, the conditioning of cPMv generated more inhibition (83%) than facilitation (17%). Inhibitory effects were most prevalent with longer ISIs (15-20ms) and facilitatory effects with intermediate ISIs (5-10ms). In comparison, the conditioning of iPMd predominantly exerted inhibition (55%) while conditioning cPMv predominantly exerted facilitation (60%). The distinct modulatory effects produced by PMd and PMv suggest the existence of a complex premotor-motor dialogue that may reflect the specific contributions of PMd and PMv to upper limb movements and to motor skills recovery following stroke.

F19: Long-term outcome and prognostication in severe disorders of consciousness: Results of a large German prospective multicenter study

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Introduction
Coma, unresponsive wakefulness syndrome (UWS), and minimally conscious state (MCS) are frequent consequences of severe brain injury, such as anoxic-ischemic encephalopathy (AIE), traumatic brain injury (TBI), or stroke. Prognostication of the long-term outcome of these patients is a challenge with only limited prospective data having been published. Among others, partial loss of brainstem reflexes, high levels of neuron specific enolase (NSE), unreactive EEG, and bilateral loss of cortical SEP-responses are believed to be highly specific negative outcome predictors. Yet, current practice parameters for prognostication may carry the risk of too pessimistic assumptions, therapeutic nihilism, and self-fulfilling prophecies. Indeed, many patients with bilateral loss of cortical SEP-responses die on the ICUs due to withdrawal of life-sustaining therapy (LST).

We present for the first time the results of a large German study on the long-term outcome of unresponsive patients in inpatient post-acute early neurorehabilitation.

Methods
Prospective observational multicenter study of patients in coma, UWS, or MCS upon admission to inpatient neurorehabilitation. The Coma Recovery Scale - Revised (CRS-R), Barthel-Index, EEG, SEP, NSE, as well as clinical scales for depression, cognition, caregiver strain, and quality of life were elicited at admission, 1, 3, 6, 12, and 24 months post admission.

Results
247 patients (mean age 55±17 years) were enrolled (42% with HIE, 31% stroke, 22% TBI) and followed for 2 years. This study population was severely affected: 26% had undergone decompressive craniectomy, 16% had bilateral loss of cortical SEP potentials, and coma duration was 4±2 weeks. On admission, 78% of patients were in UWS, 22% in MCS. Duration of specialized inpatient neurorehabilitation was 15.6±10.1 weeks. After 2 years, 13% were in UWS, 9% in MCS, 20% had emerged from MCS (eMCS), and 58% were dead. The likelihood of a favorable outcome differed between diagnoses, where TBI patients had the best chances for recovery. Interestingly, 5% of AIE patients regained functional communication skills despite bilateral loss of cortical SEP potentials. Even after one year of follow-up, some patients progressed from UWS or MCS to eMCS. We will present further detailed outcome data and trajectories of clinical patient improvement.

Discussion: We report detailed long-term outcome of the largest cohort of patients, published so far, who were so severely affected, that they would not have qualified for specialized neurorehabilitation in several countries. Yet, despite the frequent presence of strong negative prognostic markers, substantial proportions of patients regained consciousness with functional communication abilities and at least partial ADL independence. We will discuss in detail the likelihood of future recovery, depending on the individual patient situation and timeline. This will provide important information for medical decision makers and for counseling of families in the subacute situation.

F20: Investigating the neuromodulatory effects of paired associative stimulation on motor skill performance in chronic stroke

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Introduction: Paired associative stimulation (PAS) is a noninvasive brain stimulation paradigm used to induce long-term potentiation (LTP)-like plasticity in the primary motor cortex (M1), and has the potential to be used as an adjunct stroke rehabilitation intervention to enhance motor learning and facilitate functional recovery. The primary objective of our study was to assess the neuromodulatory effects of PAS on measures of cortical excitability and motor skill performance in individuals with chronic stroke and healthy individuals.

Methods: Three individuals with chronic ischemic stroke (3 females, 2 left hemisphere) and three healthy controls (2 males, 3 right-handed) have completed testing. PAS consisted of pairing median nerve stimulation of the paretic/non-dominant hand at rest with transcranial magnetic stimulation (TMS) of M1 in the ipsilesional/non-dominant hemisphere at an interval (individual N20 latency + 5ms) known to induce LTP-like plasticity. 180 pairs of stimuli were delivered at ≤0.25Hz for ~12 min. Cortical excitability and motor skill outcome measures were conducted at baseline before PAS and at 0, 30, and 60 min post-PAS. Data collected 30min post-PAS will be reported here. Cortical excitability was assessed using single TMS pulses at an intensity determined at baseline to evoke peak-to-peak motor evoked potential (MEP) amplitudes of 1mV in the abductor pollicis brevis (APB). Motor skill performance on a version of the serial reaction time task (SRTT) comprised of random and repeated sequences was assessed bilaterally. Sequence-specific skill performance was measured using reaction times during performance of the random and repeated sequences for each hand collected before and 30min post-PAS.

Results: Positive response to PAS, as demonstrated by an increase in MEP amplitude from baseline, was noted for 2/3 stroke individuals (mean: 164% of baseline) and 3/3 healthy controls (mean: 136% of baseline). After PAS, sequence-specific skill performance was improved in the paretic hand of 3/3 stroke individuals (mean: 208% of baseline), but in only 1 individual for the non-paretic hand (mean: 7% of baseline). Following PAS, improvement in sequence-specific skill performance was noted in the non-dominant hand of 2/3 healthy controls (mean: 234% baseline), whereas all three controls improved skill performance with the dominant hand (mean: 579% baseline). Changes in cortical excitability did not correlate with changes in SRTT performance after PAS across all participants.

Discussion: Preliminary findings suggest PAS may positively influence sequence-specific motor skill performance in individuals with stroke, but not healthy participants. These differences may be related to homeostatic metaplasticity mechanisms within the corticomotor system in individuals with stroke. However, both groups demonstrated increased cortical excitability following PAS, although increased excitability was not associated with motor skill acquisition. Additional data collection and analysis will further characterize the effects of PAS on motor skill performance in participants with chronic stroke and healthy individuals.

F21: Sensory function is associated with white matter structure at both baseline and in response to therapy in chronic stroke

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PURPOSE. Sensory function loss is a significant problem for stroke survivors. Sensory re-education can produce lasting improvements and therefore it is likely to be associated with changes in brain structure. The purpose of this study was to evaluate the relationship between sensory function and regional white matter structure as well as to determine a correlation between improved sensory function and changes in white matter structure.

METHODS: We treated 11 stroke survivors (>6 months post-stroke) with upper limb sensory and motor deficits. Proprioception, monofilament acuity testing and Diffusion Tensor Imaging (DTI) were collected before and after a 12-week upper limb sensory/motor learning therapy program. The monofilament score was derived by summing values obtained for 5 upper limb dermatomes (range 18.05-59.85mm). Proprioception was scored as “0” (absent) or “1” (present) for 5 upper limb joints and summated to give the overall proprioception score (range of 0-5). DTI data was processed using the longitudinal Freesurfer Tracula stream where white matter tracts are reconstructed using global probabilistic tractography. The average fractional anisotropy (FA), axial diffusivity (AD), mean diffusivity (MD) and radial diffusivity (RD) were computed for 8 bilateral and 2 interhemispheric white matter tracts. Spearman correlation analyses were used to determine the relationship between sensory and DTI measures. We used Bonferroni correction for multiple comparisons.

RESULTS: Subjects were 59±8.3 years old, 46±30 months after stroke and 54% were female. At baseline, mean monofilament score = 36.62±13.85 and mean proprioception score was 3.18±2.23. At baseline, a better monofilament score was correlated with higher RD in bilateral cingulum-cingulate gyrus tracts (ipsilesional - rho=.87,p=0.001 and contralesional – rho=.87,p=0.0004). In addition, a better monofilament score correlated with greater MD in the contralesional corticospinal tract (rho=.85, p=0.002) with greater AD in the contralesional uncinate fasciculus (rho=.85, p=0.0008). Following therapy, improvement of the monofilament score correlated with increased AD in the ipsilesional cingulum angular bundle (rho=.91,p=0.00001). For proprioception at baseline, better proprioception correlated with greater RD in the contralesional cingulum-cingulate gyrus tracts (rho=.85,p=0.007).

CONCLUSION: Sensory function after stroke seems to be related to structural integrity of bilateral white matter tracts providing communication between frontal, parietal and temporal lobes as well as in the contralesional corticospinal tract. Importantly in response to therapy, gains in sensory function are associated with an improved white matter tract structure of the ipsilesional tract connecting frontal and temporal lobes.

F22: Use of the instrumented stand and walk test (ISAW) to improve frailty assessment

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Background: Frailty is a clinical syndrome characterized by reduced reserve capacity in multiple physiologic systems and is associated with mobility disability, hospitalization, and falls. A healthy (robust) individual becomes prefrail (meeting 1 or 2 of 5 criteria: low grip strength, exhaustion, slow gait, low physical activity, and/or unintentional weight loss), and can then evolve to become frail (meeting 3 or more of the 5 criteria). There is a growing interest in the use of objective measures to predict or identify frailty status. Recently, we developed an instrumented Stand and Walk (ISAW) test to objectively characterize, with wearable inertial sensors, several domains of mobility. We hypothesized that standing, walking and turning during a cognitive task would relate to frailty status.

Methods: Eighty-nine elderly men (25 Robust, 54 Prefrail, and 10 Frail) in the Osteoporotic Fractures in Men (MrOS) cohort in Portland, Oregon completed an ISAW test at OSHU. The ISAW protocol involves standing for 30 seconds, followed by walking 7 meters, turning around, and walking back, while wearing inertial sensors on the chest, lumbar-level, wrists and feet. Subjects performed the protocol twice, with and without a dual task of reciting serial subtractions by threes.

Results: Frail people maintained slower gait speed, longer gait cycle duration, shorter stride length, and smaller foot angle at heel strike ($p<0.020$), as compared to the pre-frail and robust groups. Using standardized response mean (SRM) analysis, the same measures showed a large effect with the dual task compared to single task in the frail and pre-frail groups (SRM>1.0). Several measures of stability showed a large effect (SRM>.07) among the frail subjects: postural sway and jerkiness during standing, double support time and lateral trunk range of motion during gait, and duration and angle of turning. Other measures of gait, including step variability and foot clearance showed a moderate dual task cost (SRM<0.7), while arm range of motion and turning peak velocity had a smaller dual task cost (SRM <0.5).

Discussion: Objective measures of the ISAW test may be useful to assess frailty in older people. Several measures of gait and balance were impaired in frail and prefrail men, especially when walking was combined with a cognitive task, similar to walking during daily life. Quantification of balance and gait could be used in routine clinical assessment of frailty. In addition to studying a larger population of men and women, we believe that combining measures of various spatiotemporal parameters of mobility in people’s daily lives may enhance the sensitivity and specificity of frailty classification.

F23: Unraveling the active ingredients that underlie improved movement time in paretic reach-to-grasp

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Background: The time it takes to complete a movement task has traditionally been used to measure paretic arm functional improvement after rehabilitation. However, time-based measures like the Wolf Motor Function Test (WMFT) lack sufficient resolution to distinguish how improvement emerges in terms of movement execution.
Purpose: Here, we use a novel valid and reliable video-based rating scale (i.e., WMFT-RPS) to determine how movement execution changes when movement time improves.
Methods: Participants were part of a large phase III clinical trial, ICARE, and were videotaped performing the WMFT with the paretic and less-affected arms pre and post intervention. Movement performance for 2 WMFT items, the Lift Can and Hand to Box tasks, were rated using the WMFT-RPS for 15 individuals. Change in WMFT-RPS score pre/post intervention was compared to the change in movement time.
Results: There was a significant correlation between percent change in total WMFT-RPS and percent change in task movement time for the Can task but not the Hand to Box task. Different movement execution patterns emerged among the 15 participants that did not necessarily correspond to the change in movement time.
Conclusions: Movement time can improve as the result of a variety of movement execution strategies. However, movement execution can also change without a change in movement time, demonstrating the value of looking beyond movement time to understand post-intervention functional change.

F24: Development of a motor training paradigm for the study of motor memory formation in older healthy adults

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Background: Primary motor cortex (M1) reorganization is involved in the early stages of training-related motor memory formation. Since training-related improvement of motor function after stroke shares similar mechanisms, interventions that enhance motor memory formation are of great interest for the development of effective rehabilitation strategies after stroke. Currently employed motor training paradigms (Sawaki et al., 2003, Buetefisch et al., 2015) fail to elicit a motor memory in an older healthy population. As the stroke patient population is of older age, we aim to develop a motor training paradigm that demonstrates evidence for the formation of a motor memory in older adults after a single exposure. Based on the observation that shorter but more frequent training blocks prevent fatigue and improve motor memory retention (Delvendahl et al., 2011) we modify an existing motor training paradigm (Buetefisch et al., 2015) by fractionating the training into shorter training blocks while keeping the total number of training movements the same.

Methods: Five younger (18-30 years) and five older (50-80 years) healthy adults will complete a single session of motor training with their left hand. The training consists of six five-minute blocks of 60 auditory-cued ballistic wrist extension movements. Subjects are instructed to move a cursor, driven by a gyrometer taped to the hand, from a home position into one of four target boxes located on a computer screen by modulating the speed of each wrist extension movement. Memory formation is defined as training-related increases in peak velocity of wrist extension movements and associated increases in corticospinal excitability. These outcome measures are evaluated before, immediately after, 30 minutes after and 60 minutes after training. For measurement of the corticospinal excitability, transcranial magnetic stimulation (TMS) at increasing intensities will be applied over the extensor carpi ulnaris (ECU) hotspot of the right M1 (stimulus response curve (SRC)). We expect peak velocity of wrist extension movements and area under the SRC to increase after training and to persist for at least an hour in both age groups. We will test for training-related differences in peak velocity and area under the SRC between age groups using repeated-measure ANOVAs with alpha set to 0.05.

Results: Preliminary results demonstrate a training-related increase in peak velocity of wrist extension movements of 122.4 deg/sec for older subjects and 73.5 deg/sec for the younger subjects (old: 4, young: 4). The improved kinematics of the trained movement were associated with increases in the corticospinal excitability as measured by an increase in the area under SRC of 2.4 mV for older subjects and 2.8 mV for the younger subjects (old: 3, young: 4).

Conclusions: The preliminary results indicate that the modified training paradigm is effective in inducing a motor memory in older and younger adults.

F25: Effects of Split-Belt Treadmill Training on Gait in People with Parkinson's Disease

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People with Parkinson's disease (PD) exhibit gait dysfunction that can significantly reduce independence and thereby quality of life. Gait dysfunction is expressed as reduced step length and gait speed, increased variability in step length and step time, and increased step length asymmetry. Increased step length asymmetry has been shown to increase risk of freezing of gait episodes and falls in PD.

This feasibility study investigated whether split-belt treadmill training can reduce step length asymmetry in PD. Specifically, the immediate effects of split-belt treadmill training on treadmill and overground walking patterns in individuals with PD experiencing gait asymmetry were investigated. It was hypothesized that an appropriate increase of walking speed on the more impaired side (using a split-belt treadmill) will decrease step length asymmetry and that this will lead to improved and more stable gait patterns in people with PD.

The feasibility of the protocol was tested in 2 subjects (58 year-old male, 59 year-old female) with PD with gait asymmetry using the GRAIL split-belt treadmill system (Motekforce Link, Netherlands). Reflective markers were placed to monitor lower limb movements during treadmill walking and the Mobility Lab (APDM, USA) gait system was used during overground walking. The following series of trials were performed: (1) two 50-meter trials of overground walking at the self-selected speed, (2) treadmill walking at the self-selected speed in the tied-belt condition, (3) treadmill walking in the split-belt condition with a higher belt speed on the side with reduced step length, (4) treadmill walking in the tied-belt condition, (5) treadmill walking in the split-belt condition, and (6) two 50-meter trials of overground walking at the self-selected speed.

Subject 1 did not show substantial step length asymmetry during the initial tied-belt trial. However, when the belt speed was increased on the most impaired side, the subject walked with increased step length on that side. For subject 2, the reduced step length observed on the right side (most impaired side) was increased during the split-belt condition resulting in decreased step length symmetry index (lower value indicates better symmetry). This improvement was preserved acutely during the tied-belt trial that immediately followed the split-belt trial. Moreover, double support duration was reduced during post-training overground walking compared to pre-training overground walking.

Results demonstrated the feasibility of the protocol and indicated that step length can be increased by walking with a higher belt speed on the more affected side (side with decreased step length). In addition, step length symmetry can be improved by choosing appropriate speeds on each side during the split-belt condition. If these benefits can be observed in a larger sample and sustained, such training can be provided as long-term rehabilitation to improve gait symmetry and improve mobility in people with PD.

F26: Comparison of Transcutaneous Electrical Stimulation and Functional Electrical Stimulation for Lower Limb Spasticity in Spinal Cord Injury

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Background: Electrical stimulation is a known adjunct to physical therapy for attenuating spasticity. Spinal spasticity presents with different behaviors such as spasms and the optimal stimulation modality to combat spinal spasticity is still unclear. We aimed to compare the effects of transcutaneous electrical nerve stimulation (TENS) and functional electrical stimulation (FES) on lower limb spasticity in individuals with spinal cord injury (SCI). Further, we measured spasticity at different time points following each intervention to estimate the duration of effect.

Methods: Ten participants [age (mean ± S.D.): 39 ± 1.36 years, spinal injury level: C3-T11, duration (mean ± S.D.): 8.8 ± 9.75 months post SCI] with spasticity in lower limb muscles were recruited for this study. Two patients had complete SCI while 8 patients had incomplete SCI. Spasticity was measured by the Modified Ashworth Scale (MAS) and Spinal Cord Assessment Tool for Spastic reflexes (SCATS). Measurements were collected at baseline and immediately, 1 hour and 4 hours following each intervention. Since the MAS measures tonic spasticity, we incorporated the SCATS as an assessment tool as it accounts for spasms, and clonus which are commonly observed spastic behaviors in patients with SCI. Our inclusion criteria were spasticity (Grade ≥1 as per MAS) in hip adductors or quadriceps or gastro-soleus caused by spinal cord injury, and presence of ankle jerk indicating the recovery from spinal shock. Each participant underwent a single session of electrical stimulation for 30 minutes with TENS, and FES in a cross over fashion. An interval of 24 hours was provided between each intervention to minimize carry-over effects.

Results: There were no differences between FES and TENS on lower limb spasticity (i.e. MAS and SCATS) at different time points. Hip adductor and knee extensor spasticity showed statistically significant improvements after four hours of TENS ($p=0.002$) and FES ($p=0.01$). There were no differences in plantar flexor spasticity with either TENS or FES. There were significant reductions in SCATS which lasted for 1 hour with TENS ($p=0.002$) and 4 hours with FES ($p=0.001$).

Conclusion: We report that a single session of TENS or FES shows a favorable reduction in spasticity for approximately four hours in patients with SCI. We recommend TENS in setups which call for cost effectiveness and portability, and FES for patients who predominantly present with spastic reflexes. Electrical stimulation with TENS or FES could be incorporated prior to physical therapy interventions for sustained reduction in spasticity.

Key words: electrical stimulation, spasticity, spinal cord injury, transcutaneous electrical nerve stimulation, functional electrical stimulation

F27: Training related improvement of hand kinematics is associated with less co-contraction of antagonistic forearm muscles in chronic stroke patients

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Background: Functional impairment of the hand is common after ischemic stroke of the middle cerebral artery. There is interest in using repetitive transcranial magnetic stimulation (rTMS) as a tool to support motor recovery. Preliminary analysis indicates that the concurrent application of rTMS over the ipsilesional primary motor cortex (M1) during motor training enhances training-related increases in wrist function compared to sham rTMS. Based on evidence that abnormally high amounts of co-contraction between an agonist and antagonist muscle can obstruct normal motor performance, a decrease in co-contraction may underlie the functional improvements by chronic stroke patients. Here we tested the hypothesis that co-contraction would decrease after hand motor training.

Methods: Twenty patients with chronic stroke affecting the primary motor system completed 360 ballistic wrist extension movements (0.2Hz, jittered) with their affected arm for 5 consecutive days. Movement-related EMG from every second wrist extension movement triggered rTMS (0.1 Hz) over ipsilesional M1 during the motor training. Patients were randomized to receive either rTMS (n=10) or sham rTMS (n=10). Before and after the five days of training, patients completed 5 auditory-cued ballistic wrist extension movements. The initial peak acceleration of the extension movements was calculated from data collected by a two-dimensional accelerometer mounted on the hand. Muscle activity during the extension movements was collected from EMG skin surface electrodes on the extensor carpi ulnaris (ECU), a muscle that acts as an agonist and the flexor carpi ulnaris (FCU), a muscle that acts as an antagonist. To determine the relationship of movement-related ECU and FCU muscle activity, a co-contraction index (CoI) was calculated for each extension movement, defined as (|ECUpre200 -ECUrest|)/(|FCUpre200 - FCUrest|). ECUpre200 and FCUpre200 was the average amplitude of the rectified EMG in the 200ms prior to movement onset. ECUrest and FCUrest was the average amplitude of the rectified EMG in a 50ms window prior to the auditory cue. Greater CoI indicates less co-contraction. Abnormality in the co-contraction of the stroke patients was tested by comparing the average CoI before training to the average CoI of 10 healthy subjects.

Results: Preliminary results were calculated from 10 stroke patients (7M, 61.20±14.17 years) and 8 healthy subjects (2M, 64.13±8.18 years). At baseline, healthy subjects had a greater peak acceleration and higher CoIs than the stroke patients. After training, peak acceleration increased in all stroke patients regardless of the intervention. This was associated with increases in CoIs, suggesting that the activity of the ECU muscle was greater than activity in the FCU muscle in the 200ms prior to movement onset.

Conclusions: Compared to healthy subjects, stroke patients have more co-contraction of the ECU and FCU muscle. Training-related increases in peak wrist acceleration is associated with training-related decreases in co-contraction of muscles supporting the training movement.

F28: Impact of enhancing expectations on self-efficacy and motor learning in individuals with Parkinson's disease

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Reduced self-efficacy has been demonstrated as an independent predictor of postural instability and gait deficits for individuals with Parkinson's disease (PD), leading to the possibility that self-efficacy may be a potential target to improve motor performance in PD. Studies in non-disabled adults have shown that boosting self-efficacy via increasing an individual's expectations for future success can enhance motor performance and learning. However, this positive effect remains to be determined in PD. This study aims to investigate the impact of enhancing expectation on self-efficacy and motor learning when individuals with PD practice a novel balance task.

Twenty participants with PD practiced balancing on a stability platform by keeping the platform level for as long as possible. Participants were assigned to an enhanced expectancy (EE) group or a control group. At early practice, the EE group received a statement designed to enhance expectation of future task success while the control group received no statement. Feedback was provided to both groups after each 30-s trial in the form of total time in balance, calculated as accumulated time when the platform position was within +/-5 degrees from horizontal during 30 seconds. Total time in balance and continuous time in balance, defined as the mean duration when the platform was maintained within +/-5 degrees, were assessed during practice and at a retention test conducted 24 hours later. Self-efficacy for 3 task performance levels (balancing for 10, 15 and 20 seconds) were assessed at 4 time points, while a motivational questionnaire was completed by each participant following practice and retention.

Self-efficacy of the EE group increased significantly after the statement only for the medium performance level (i.e. balancing for 15s) (p= .04). Enhanced self-efficacy did not appear to affect total time in balance. No group difference was observed in total time in balance during practice (p= .97) and at retention (p= .07). However, there was a trend that the EE group demonstrated longer continuous time in balance than the control group at retention (p= .08). In addition, the EE group reported greater nervousness than the control group during practice (p= .02) and at retention (p= .04), an unexpected finding that may have counteracted the effect of enhanced self-efficacy. Individual data within the EE group revealed that the participants who reported high nervousness level demonstrated shorter total time in balance than those reporting low nervousness level during practice and at retention. The results suggest that enhancing expectation appears to boost self-efficacy and result in a modification of motor control that may reflect longer durations of balance stability in PD. The negative impact of nervousness on motor performance shown in the preliminary analysis may suggest a potential importance of improving self-efficacy without inducing nervousness to clinicians.

F29: A Novel Structural Biomarker of Motor Outcome in Acute Stroke Patients

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Introduction

Lesion load of the Corticospinal Tract (CST-LL), weighted for the geometric size differences while it traverses the brain to the spinal cord, can predict 69% of the variance in 3 months motor outcome of acute stroke patients (Feng et al., 2015). Similarly, previous voxel-based lesion symptom mapping (VLSM) studies found that lesion location may also have a close relationship with motor outcome (Lo et al, 2010, Cheng et al., 2014). In the current study, we combined a VLSM technique (i.e., identifying the brain voxels associated with motor impairment) with a CST-LL approach, giving particularly weight to voxels that are both part of a canonical CST and a VLSM map of motor impairment to test our hypothesis that a combined VLSM-wCST-LL model will be a better model for motor outcome predictions than CST-LL alone.

Methods

We derived the VLSM map from a group of 50 chronic patients with variable amounts of motor deficits (Zhu et al., 2010), using nonparametric mapping (NPM) to relate voxels of patients' lesioned regions to motor behavioral scores assessed by the Upper Extremity Fugl-Meyer (UE-FM). Multiple comparisons were corrected for alpha inflation with an FDR $p<0.05$ threshold, and permuted 1000 times. Resulting VLSM T-maps were multiplied using our previous established probabilistic CST maps (Feng et al., 2015), and then summed to form a canonical VLSM-weighted CST tract. Individual lesion maps from 76 acute stroke patients with motor impairments were overlaid onto the VLSM-weighted CST map to calculate lesion load. Linear regressions were run to determine predictions of 3-months UE-FM motor outcome in a group of 76 acute stroke patients using lesion load. We controlled for Days of therapy (D_T).

Results

The VLSM analysis determined that voxels in the pre-central gyrus, the descending motor tracts, premotor regions, and the corona radiata were significantly related to chronic motor impairment as measured by the UE-FM. Thus, this VLSM-map constitutes a motor impairment map.

Combining this VLSM map with our previously established canonical CST to calculate VLSM-weighted CST-Lesion Loads of a group of acute stroke patients with motor impairment predicted a higher degree of outcome variance at 3 months than the wCST-LL by itself. The VLSM-weighted CST-Lesion Load was the better model to predict motor outcome at 3 months.

Conclusions

Akaike Information Criterion results confirmed with 99% certainty that VLSM-weighted CST-LL is the superior fit model compared to the weighted CST-LL model in predicting 3 months outcome , when combined with UE-FM baseline assessment.

F30: **AbobotulinumtoxinA injection in muscles outside the gastrocnemius-soleus complex in pediatric patients with lower limb spasticity**

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Although botulinum neurotoxin is not currently approved in the US for the treatment of children with focal spasticity associated with cerebral palsy (CP), it has been used for decades in this patient population.[1] Children with spasticity in the lower limb need to be injected in distal and/or proximal muscles in accord with their pattern of impairment. Recently, a large randomized trial evaluated a single dose of abobotulinumtoxinA ([ABO] 10 or 15 U/kg/leg) versus placebo injected into the gastrocnemius-soleus complex (GSC) for dynamic equinus foot deformity in children with CP.[2] An open-label extension of the study allowed injections into muscles outside the GSC. The dose was 10 U/kg/lower limb (20 U/kg total for bilateral injection) for the first cycle, increased or decreased by ≤5 U/kg/limb in each subsequent cycle to a maximum 20 U/kg/limb (30 U/kg for bilateral injections), to a maximum of 1000 U/patient. Hamstring injections were permitted in all cycles; other lower limb muscles could be injected in cycle 2 and after. Total volume injected: 2.0 mL/limb (maximum 1.0 mL outside the GSC).

A formal search of the literature identified 2 randomized, placebo-controlled trials in which ABO was injected into ex-GSC muscles for pediatric CP. Moore compared injections of ABO or placebo (every 3 months for 2 years) in 64 children.[3] Maximum ABO was 15 U/kg for Cycle 1 and increased 5 U/kg per cycle (maximum 30 U/kg at Cycle 4). ABO doses in Cycle 1 were: GSC 10.2 U/kg/muscle (range: 7.4-15.3; n=23), hamstrings 7.0 U/kg/muscle (range: 3.8-8.4; n=6), and adductors 6.4 U/kg/muscle (range: 3.8-7.5; n=4). In Cycle 4, doses were: GSC 17.6 U/kg/muscle (range: 7.6-30.8; n=19), hamstrings 11.2 U/kg/muscle (range: 7.5-15.1; n=9), and adductors 7.7 U/kg/muscle (range: 6.7-10.0; n=3). Mall compared ABO vs placebo for the treatment of hip adductor spasticity in 61 children with CP.[4] ABO was administered at a dose of 30 U/kg (maximum 1500 U) injected bilaterally, with 20 U/kg in the adductors and 10 U/kg in the medial hamstrings. Due to different study designs there are varying degrees of efficacy, however ABO had a safety profile consistent with previous clinical experience.

The open-label extension of the Delgado 2016 trial has been completed and the results will be presented when available.

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F31: Improved functional connectivity in the dorsal attentional network is specific to spatial neglect improvement following prism adaptation therapy

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Prism adaptation is a visuomotor phenomenon resulting from goal-directed limb movements toward visual stimuli while wearing yoked optical wedge prism lenses, which shift the entire visual field. Adaptation requires no top-down strategy and occurs automatically. Since 1998, 19 clinical studies reported that a prism adaptation therapy (PAT) protocol enhances function in people with spatial neglect after right brain injury who demonstrate deficient attention and action in the left side of the space. The precise underlying neural changes underlying effective PAT are not yet understood. Based on a previous report, we hypothesized that PAT would induce bilateral activation of a dorsal attentional network (DAN), and increase connectivity of this network.

Two participants –Patient 1, a 51-year-old woman, and Patient 2, a 43-year-old man, completed behavioral testing two weeks after right brain stroke. Patient 1's lesions were within the posterior insula and surrounding white matter. Patient 2's lesions were smaller, and subcortical, largely involving the region of the putamen and associated white matter. Both patient had spatial neglect on the Behavioral Inattention Test (BIT) conventional subtest, a set of paper-and-pencil tasks (neglect = score of 129 or less of 146; higher score = better performance). Participants also underwent neuroimaging including anatomical and resting-state functional MRI (RS-fMRI). During each session of prism adaptation therapy (PAT), participants wore prism lenses while making repeated arm movements to bisect a line or mark a circle target. As per standard protocol, participants completed PAT, one session a day, over two weeks (Patient 1: 8 sessions; Patient 2: 10 sessions). After the final session, participants again underwent brain RS-fMRI scanning.

After PAT, Patient 1 improved (BIT pre: 60, post 83). Resting state data was analyzed using AFNI software. A seed (radius 3 voxels) placed in the right superior temporal gyrus (STG), a region highly associated with the DAN, and we observed increases in both inter and intra-hemispheric activity, consistent with our a priori hypothesis. After PAT, Patient 2 did not improve (BIT pre: 113; post: 107). . In this participant, decreases in inter-hemispheric and intra-hemispheric activity correlating with the right STG seed were observed. Our results suggest that increased functional activity and connectivity in bilateral frontoparietal regions, previously reported after PAT, are specifically associated with spatial neglect improvement, and not PAT exposure. Further research in patients with different lesion and spatial neglect deficit profiles is needed, to clarify how network-level physiological parameters might serve as biomarkers of neglect recovery.

F32: Evidence of common structures in the performance of functional tasks in individuals with moderate upper extremity impairment after stroke

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Movement after stroke is often characterised by the use of compensatory movement patterns rather than restoration of pre-stroke motor control. Factors such as task difficulty and similarity will likely affect the movement strategy chosen. The recently developed WMFT-RPS is a valid and reliable tool that is an extension of the Reaching Performance Scale (Levin et al 2004) , and can be used to quantify movement quality of task items from the Wolf Motor Function Test (WMFT), a common outcome measure used in rehabilitation research.

We hypothesized that if tasks are of a similar difficulty and share a similar underlying structure, individuals with motor stroke and primarily moderate impairment will use similar movement performance strategies, compared to the strategies used to perform tasks that do not share a common structure, and this will be reflected in their WMFT-RPS scores.

In this study, we applied the WMFT-RPS to four arm movement items ("lift can", "hand to box (front)", "lift pencil" and "lift paperclip") from the WMFT. Both the pencil and paperclip tasks require precision grasps, the can task a power grasp, and for the box task no prehension is required. Thus, we expected that pencil and paperclip tasks would share a common structure that was not shared by the can or box tasks.

The WMFT-RPS tool was applied to data collected as part of the ICARE trial (ClinicalTrials.gov ID: NCT 00871715). Videos of 29 individuals with stroke performing the WMFT with both their less affected and more affected arms were reviewed and scored. Scores comprised six components: Trunk, Shoulder, Elbow, Movement Continuity, Prehension and Task Completion. Similarity between scores on different pairs of tasks was ascertained by calculating the angles between vectors formed from the 6 score components. Wilcoxon Signed Rank tests were used to look for significant differences between task pairs. Performance on the pencil and paperclip tasks were found to be most similar to each other, and the angular difference between scores on these tasks was significantly different from the angular difference between scores on the can task and each of these tasks ($p<0.01$). Similar results were found comparing the box task to the pencil and paperclip tasks, with the prehension component removed from the score to allow comparison.

In conclusion, we found that WMFT-RPS scores can reflect similarities and differences in performance that are consistent with whether tasks share a common structure.

F33: Underlying contributors to visuomotor learning change with aging

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Introduction: Many visuomotor skills, such as driving a car, are mediated by a combination of skilled limb movement and skilled visual search (voluntary eye movements used to actively gather visual information from the environment). We know that limb movement and visual search efficacy diminish with aging, but we do not know if their contributions to visuomotor learning also change with aging. Here we examine the extent to which visuomotor learning and its underlying processes change across adulthood. **Methods:** Eighteen young adults and eight older adults used an upper-limb robotic device within a virtual environment to practice a bimanual visuomotor task one day a week for six weeks. In the Object Hit and Avoid (OHA) task, 300 objects (8 geometric shapes) moved towards participants, who used virtual paddles attached to each hand to hit away target objects (2 shapes, n=200) and avoid hitting distractor objects (6 shapes, n=100). Participants completed six trials of the OHA task each week for a total of 36 trials. Hand and eye kinematics were collected and used to compute measures of *Task Performance* (percent of targets hit), *Hand Movement Efficacy* (horizontal hand speed), *Visual Search Efficacy* (percent of objects pursued with the eyes), *Eye-Hand Coordination* (distance between the eyes and hand at the time of target contact) and *Visual Recognition Speed* (mean distractor pursuit time). **Results**: Both groups showed similar improvements in task performance, though young adults exhibited better baseline task performance. Improvements in task performance in both groups were associated with improvements in visual search efficacy and eye-hand coordination. However, young adults (but not older adults) showed improvements in hand movement efficacy, whereas older adults (but not young adults) showed improvements in visual recognition speed. **Discussion:** Our findings suggest that, across adulthood, visuomotor learning is mediated by a combination of distinct and overlapping mechanisms. Improvements in visual search efficacy and eye-hand coordination contribute to visuomotor learning at all ages. However, motor learning (hand movement) is emphasized in young adults and perceptual learning (visual recognition speed) is emphasized in older adults.

F34: Effects of a Single Bout of Training with a Novel Mechano-sensory Rehabilitation Bike on Paired-reflex Depression of the Soleus H-reflex in Individuals With Incomplete Spinal Cord Injury

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Background: Spinal cord injury (SCI) is a life changing injury that may cause loss of two major abilities: bipedal locomotion, and balance. In the case of incomplete SCI (iSCI), there is still some communication between the brain and the spinal cord. The remaining communication is impaired due to injured neural circuits; which can lead to additional neurological complications, such as chronic pain or spasticity, limiting the range of motion in the lower limbs. Studying the H-reflex is an indirect method to assess spasticity occurring due to maladapted reflexes within the spinal networks.

Objective: The purpose of the present study was to evaluate the effects of training with a novel mechano-sensory rehabilitation bike (MSR) on plasticity of the neuronal pathways in individuals with iSCI. This novel bike stimulates multisensory inputs including foot load receptors and hip position sensors using mechanical stimulators at the pedals and passive cycling, respectively, since both inputs have an important role in regulating the pattern of walking.

Methods: To assess the effect of training, five iSCI individuals with American Spinal Injury Association Impairment Scale D participated in two half-hour sessions of MSR training; one with mechanical stimulation, and one without. The primary outcome measure was paired H-reflex depression with inter-stimulation intervals (ISI) ranging from 45-200 milliseconds.

Results: The comparison of reflex depression at pre- versus post-MSR training revealed that a single bout of training yielded a trend towards greater H-reflex depression only in iSCI participants who had spasticity (according to the Modified Ashworth scale). In both spastic and non-spastic groups, we saw trends toward reflex modifications at the longest ISI (200 ms). In participants with spasticity a trend for an effect of training with mechanical stimulation was seen at 200ms ISI. Reflex depression was 23% higher after training with mechanical stimulation versus 7.1% without mechanical stimulation. It is plausible the findings indicate engagement of the supraspinal networks in modifying the H-reflex because there was enough time (>60 ms) for the ascending and descending signals to respectively travel to and from both supraspinal and corticospinal structures.

Conclusion: Training with MSR induces a rhythmic and consistent passive range of motion exercise without involvement of postural control mechanisms. We suggest it could be a complementary adjunct to locomotion training and/or spasticity medications. Training with MSR is affordable and individuals with iSCI are able to use it independently at home, with minimal assistance. Future research will further examine the role of cortical spinal pathway modulation as a possible mechanism for observed functional changes in balance and locomotion.

F35: Neural Mechanisms of Upper Limb Virtual Mirror Visual Feedback in Acute Stroke:A Single-Case Study

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Mirror therapy has been suggested to drive inter-hemispheric communication resulting in a more balanced hemispheric activation. Virtual reality (VR) mediated mirror visual feedback (VR-MVF) may facilitate such intervention to engage stroke survivors in game-like exercises early in the acute phase, where the benefits of neuroplasticity are suggested to be higher. In this study, we investigated whether VR-MVF facilitates ipsilesional cortical excitability resulting in a more balanced hemispheric activation. For this purpose, a 60-year-old right-handed (Edinburgh test > 95) male subject was recruited at the acute neurorehabilitation unit of CHUV (Lausanne, Switzerland), with the intervention starting 9 days post stroke. Pre-intervention medical evaluation (on day 8 post stroke) revealed an ischemic stroke (left paramedian pontine), resulting in hemiparesis on the right side (NIHSS = 6; Fugl-Meyer Assessment of Upper Extremity (FMA-UE): total motor function = 26/66, joint pain score = 21/24).
The patient performed planar reaching exercises that implied active shoulder and arm movements for approximately 1 hour per day using a VR platform (MindMotionPRO, MindMaze SA). He completed 400 repetitions during 3 sessions in 3 consecutive days. Two visual feedback mechanisms were used: (i) direct mode (left arm movements are translated to the ipsilateral (left) arm of the avatar); and (ii) mirror mode (left arm movements are translated to the contralateral (right) arm of the avatar). We recorded 16-electrode EEG in 10-20 system from frontal, central and parietal areas while performing the reaching task. We then extracted movement-related cortical potentials (MRCPs), whose negativity is thought to reflect cortical excitability. During his hospitalization, the patient also undertook thrombolysis treatment and nearly 1 hour of standard physiotherapy per day. On the day of discharge (day 13; NIHSS = 3), we observed an improvement in arm synergy (FMA-UE: total motor function = 32/66) and a reduction in the joint pain (score = 24/24).
Non-paretic arm movement in the direct mode showed negative MRCP in the electrodes contralateral to the movement (e.g. CP2 electrode), as expected. With the mirror feedback, such lateralization was reduced and MRCP negativity was also observed on the ipsilesional side (e.g. C1 electrode). Additionally, the difference between the two conditions (mirror non-paretic vs. direct non-paretic) revealed a significant increase in MRCP negativity ipsilateral to the moving arm (FC3 electrode, 95% confidence interval (CI): 0.758, 13.2). Importantly, we observed a similar increase in excitability ipsilateral to the movement in a group of age-matched healthy participants (n=13; FC4 electrode, 99.9% CI: 0.81, 13).
We conclude that administration of VR-MVF is feasible in the acute phase, where the potential benefits of neuroplasticity are higher. The observed functional improvements suggest that VR-MVF training may accelerate the motor recovery when applied in the acute phase, even for patients with low motricity.

F36: Individuals with left hemiparesis show asymmetries in contralateral force matching tasks

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Introduction
Following a stroke to the right or left hemisphere the contribution of changes in hand preference and grip strength were shown to be related to motor recovery and directional differences in the control of grasp force. The present work investigated the extent to which the difference between the strength of the right and left hand contributed to performance of contralateral force matching tasks. It was hypothesized that greater grip strength differences between the hands would be related to greater opposite hand matching errors.

Methods
Three groups of participants (22 right hemisphere damage, 27 left hemisphere damage and 27 age-gender matched controls) completed clinical assessments and performed hand-grasp tasks using instrumented strain gauges embedded with force sensors. For force matching tasks, participants matched a 20% reference force with the opposite hand in two conditions; 2 s after the presentation of the reference force (Contralateral Remembered) and simultaneously with the presentation of the reference force (Contralateral Concurrent). The matching force, performed without visual feedback, was generated from an internal representation of force and required interhemispheric transfer of force related information. Force matching performance was quantified as the relative force error.

Results
For grasp force matching, the ANOVA showed a significant three-way interaction for matching hand x condition x group ($F_{(2, 72)} = 5.2$, $p < 0.01$) for relative error. Individuals with right hemiparesis showed no significant differences between right and left hand matching errors for contralateral matching tasks. However, individuals with left hemiparesis showed significant differences between right and left hand matching. Matching errors were at least twice as great when matching left hand reference forces with the right hand ($p < .01$) when compared to matching right hand reference forces with the left hand. Further, for those with left hemiparesis, greater differences in handgrip strength were associated with greater declines in motor recovery ($r = -.713$; $p = .000$).

Discussion
Individuals with left hemiparesis showed greater asymmetries in contralateral matching tasks when compared to individuals with right hemiparesis and controls. Previous literature suggests recovery post stroke may be improved with additional activation of the ipsilesional sensorimotor regions. Interhemispheric training with visual feedback may offer a way to train the ipsilesional cortex in patients with poor motor recovery.

F37: Callosal integrity and dynamic stability of gait in people with parkinsonism

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Introduction
People with parkinsonism (PD) are at an increased risk of falls due to instability during walking. Impaired interhemispheric, communication has been suggested as a cause for decline in dynamic gait stability. Here, we studied the association of genu collosal integrity and measures of dynamic gait stability. The 'margin of stability' is a measure of how close a person is to instability, taking the spatio-temporal accuracy of medio-lateral foot placement with respect to the body center of mass into account.

Methods
We recruited 10 subjects with idiopathic PD, 10 subjects with frontal gait disorder, and 8 age-matched healthy controls. All subjects underwent diffusion tensor imaging (DTI) to assess white matter microstructural integrity through the genu of the corpus callosum. Gait was assessed using an instrumented walkway (GAITRite). Margin of stability was calculated as the minimal difference between lateral CoP and extrapolated CoM during gait. Subjects performed three trials of 8 meters at a comfortable walking speed.

Results
Significant correlations between genu fiber tract microstructural integrity (FA) and stride width (Spearman's rho -0.82) and margin of stability (Spearman's rho -0.77) were found for the subjects with frontal gait disorders but not for the idiopathic PD or healthy controls. Subjects with frontal gait disorders walked with a wider stride width and a larger margin of stability than subjects with idiopathic PD and healthy controls ($p<0.01$). The margin of stability increased with stride width (Spearman's rho 0.76, $p<0.001$). Coefficient of variation of margin of stability decreased with stride width in the Frontal and PD groups. Trunk displacement in the coronal plan was not different among the groups.

ConclusionThe inability for people with frontal gait disorders to tandem walk is related to mediolateral instability. By assuming a wide stride width, people with frontal gait disorders aremore stable and less variable while walking than PD or control subjects with their normal gait width.

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F38: Modulating brain state using a novel TMS-based neurofeedback approach

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Various transcranial brain stimulation techniques have been used in an attempt to modulate excitability of the human corticomotor system, often with weak or mixed results. To date, there exists no reliable method to robustly upregulate or downregulate the state of the motor system, which would be desirable for a range of neurorehabilitation applications. Our aim was to use neurofeedback of the size of motor evoked potentials (MEPs) in response to transcranial magnetic stimulation (TMS), to train participants to self-modulate their own brain state. The goal was to harness experimental control over the excitability of the motor system, in order to investigate the oscillatory brain activity that mediates these different states, using electroencephalography (EEG).

Separate sessions (300 trials each) were carried out for upregulation (UP) and downregulation (DOWN) of MEP amplitude. In the UP condition subjects were rewarded for larger than average first dorsal interosseous (FDI) MEPs, with visual feedback showing amplitude as a green bar, a positive sound-byte, and a small financial incentive. Smaller than average MEPs were not rewarded, a red bar displayed the amplitude, and a negative sound-byte was heard. The reverse occurred in the DOWN sessions. Background muscle activity was monitored throughout and each trial only commenced when muscles were sufficiently relaxed. The final 60 trials of training occurred during simultaneous EEG recording.

MEP amplitudes in the muscle from which neurofeedback was provided were significantly altered from baseline by the end of 150 DOWN training trials (all $p<0.005$) and 240 UP training trials (all $p<0.01$). No changes in MEP amplitude occurred in a nearby control muscle that was not providing neurofeedback. EEG data collected during upregulation and downregulation suggests that high and low levels of corticomotor excitability are mediated by oscillatory signatures in the alpha and beta bands that are distinct compared to those in the gamma band.

Our approach uses brain stimulation in a non-traditional way to achieve robust neuromodulation. Using this method to harness experimental control over the excitability of the motor system opens many possibilities for future investigations of how altered brain state influences motor behaviour and recovery of motor function in a neurorehabilitation context.

F39: Improved arousal and motor function using zolpidem in a patient with HIV-associated CNS lymphoma: a case report.

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Introduction: Zolpidem is a non-benzodiazepine hypnotic used for the treatment of insomnia and has been observed to paradoxically improve arousal in patients with disorders of consciousness (DOC), such as the vegetative or minimally conscious states (MCS). This phenomenon has primarily been reported in patients with brain injury secondary to trauma, non-traumatic anoxia, or stroke. There is little information on its use in DOC patients with intracranial space occupying lesions.

Case Report: A previously healthy 24-year old man presented to his local emergency department with several weeks of worsening frontal headache, impaired coordination, and behavioral changes. Neuroimaging revealed a left frontal lobe lesion affecting the basal ganglia along with satellite lesions in the left frontal lobe and cerebellum. Biopsy results were consistent with primary CNS B cell lymphoma. He was subsequently found to be HIV positive, and started on retroviral therapy. After one week, he developed multiple episodes of generalized seizure activity and was intubated for respiratory failure. His hospital course was also complicated by recurrent infections, autonomic dysregulation, and pulmonary embolism. After being weaned from sedation, he was in a MCS, and inconsistently followed simple commands, including answering yes/no questions using nonvocal gestures. His neurologic exam did not significantly improve despite receiving chemo- and radiation therapy. Repeat MRI showed interval progression of his lymphoma with increase in size of the frontal lobe and cerebellar lesions.

On hospital day 126, zolpidem was trialed to improve the patient's level of cognitive awareness. Functional assessment using the Glasgow Coma Scale (GCS) and the Disability Rating Scale (DRS) were made before and 45 minutes after administration of 10mg zolpidem. He initially appeared more somnolent, but quickly awoke with tactile stimulation, and was noticeably more interactive than prior to receiving the medication. He displayed functional object use, such as demonstrating how to drink from a cup and use a pen. There was improvement in both GCS and DRS, primarily in the domains of motor function (before/45mins after, GCS 9/11, DRS 23/20). Verbal scores were not able to be assessed, as an uncapped trachesotomy impaired his ability to speak. Two days later, a repeat trial assessing at 1,2, and 4 hours post-zolpidem also included the Coma Recovery Scale- Revised (CRS-R). Across all 3 outcome measures, there was initial functional decline due to sedation at 1 hour, followed by increased arousal at 2 hours, and return to near-baseline at 4 hours (pre/1/2/4hrs post, GCS 9/6/11/10, DRS 23/25/20/24, CRS-R 13/6/19/not assessed).

Conclusion: Zolpidem may be effective in improving arousal and motor function in patients with intracranial space occupying lesions. A lower dosage may be necessary to avoid oversedation. Larger controlled trials are needed to better understand zolpidem's efficacy for this clinical application.

F40: Rasch Analysis of UE Fugl-Meyer in the ICARE Stroke Trial: Effects of Rescaling on Clinical Assessment and Measurement of Recovering Motor Control

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Purpose: Post-stroke motor recovery is often assessed using measures that employ ordinal scales, including the Fugl-Meyer (FM), Stroke Impact Scale (SIS), and Reintegration to Normal Living Index (RNLI). However, measuring change in motor function using ordinal scales presents important drawbacks because items may not scale equally at: (1) different levels of the scale or (2) over time in the same individuals even when similar data collection protocols are followed. This may limit the interpretation of change in motor function in response to therapy or to the passage of time.

To counter these drawbacks, we are using Rasch-based modeling on the upper-extremity portion of the Fugl-Meyer (UEFM) that was administered during the ICARE RCT [1]. By rescaling the distribution of motor outcomes as a function of patients' motor impairment and item difficulty, we will obtain item response measures that remain invariant across individuals over time, potentially allowing a more accurate interpretation of change in motor function in this moderately impaired cohort post-stroke.

Methods: Analyses are in process and will be reported. Specifically, we are examining whether relative item difficulties on the UEFM remain invariant over time, at: study recruitment (T1), post intervention (T2), and at 6 and 12 months post-randomization (T3 & T4). We are applying Rasch analysis with T1, T2, T3, and T4 UEFM data "racked" as one group of participants responding to four different sets of items, and with T1, T2, T3, and T4 UEFM data "stacked" as four different groups of participants responding to one set of items, in order to identify relative item difficulties of UEFM at various times post stroke, and in response to treatment. The goal of this analysis is to compare the relative hierarchy of UEFM item difficulties up to 1-year post-randomization (~13.5 months post-stroke) with baseline measurement (~45 days post-stroke) to better understand the particular combinations of multi-joint UE movements that are relatively easier or difficult to recover in this population. Secondly, we will identify the UE movements (measured by change in Rasch-rescaled UEFM scores at T1 vs. T4) that best predict Rasch-rescaled scores on selected domains of the RNLI, and SIS.

Conclusion: We anticipate clinically important results that will identify patterns of upper extremity movements (measured by UEFM) that are most or least likely to show improvement post-stroke over time. From a basic motor control perspective, examining the hierarchies of UEFM item difficulties over time post-stroke may also result in better understanding of the recovery patterns of synergistic UE control, yielding insights into central coupling of multi-joint UE movements.

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F41: Implementation of fractional calculus order-based methods in store-and-forward telehealth systems for the purpose of stroke and neurodegenerative disorders rehabilitation

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Nowadays telemedicine enables providing quick and reliable expertise from various specialists and the results can be virtually stored in one place. This makes the hospital care easier and increases the choice of the medical specialists to also those not being local.

The authors of this paper propose a store-and-forward telehealth system for the purpose of stroke and neurodegenerative disorders rehabilitation with the implementation of non-integer order-based methods. Such methods would be applied in analysis of biomedical data such as fMRI, EMG or EEG.

The implementation of stable numerical algorithms in realisation of non-integer order system is currently one of the largest challenges for the numerous research groups across the globe. In this paper - the methodology for the application this class of systems using the approximate time for the Oustaloup filtering (BFF - Bi-Fractional Filters) was presented. The developed algorithms were implemented using Python. The initial tests were also carried out on the Raspberry Pi platform.

This paper presents online filtering of various biomedical data such as EEG, EMG and fMRI. The data was processed with the implementation of the Raspberry Pi environment. This is because the direct implementation of the non-integer methods is impossible, so the realization was conducted with the use of temporary Oustaloup method. The initial study results are very promising and prove that application of non-integer filtering is possible, efficient and quick.

As mentioned above - the research is currently of initial study stage and the idea of using non-integer filtering in real-time signal processing is still being tested. However the obtained results are promising and show wide range of filter design possibilities. Implementation of such filtering in fractional form is (as also stated above) numerically impossible - so the approximation has to be taken into account due to occurrence of various numerical errors. The high order of the approximation enables more accurate response of the applied filters, but it may provide less numerical stability.

Although the implementation of fractional filtering is still not very popular - the authors assume (in accordance with their own experience and with the literature study) that it will become widely used in the near future due to its efficiency and wider potential in development of frequency filters' characteristics. The proposed signal processing method also offers more flexible adjustment of the frequency characteristics.
To sum it up - demands for telemedicine solutions are constantly increasing in order to meet global health needs. This because of little accessibility of care, expertise and technology and also because of shortage of experts. Various telehealth solutions enable access to the highest level pf expertise and care through the most advanced modern technology, which bridges medicine, neurosciences and computing.

F42: Vibrotactile P300 BCI for communication with persons with late-stage ALS in a completely locked-in state (CLIS)

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Amyotrophic lateral sclerosis (ALS) is a progressive neurodegenerative disorder that impairs voluntary movement and speech. In the later stages, patients may have complete locked-in syndrome (CLIS), with anarthria and no reliable control of voluntary movements. Since these patients typically have no way to communicate and may experience cognitive decline, their conscious awareness may also be in question.

mindBEAGLE is a hardware and software platform designed to use brain-computer interface (BCI) technology to assess conscious awareness and provide communication based on EEG activity. While mindBEAGLE was developed for persons with disorders of consciousness, the current work evaluates mindBEAGLE with two late-stage ALS patients at the ALS Center at the University of Palermo. Both subjects had CLIS, and medical staff and family members were not able to verify their conscious awareness through conventional means, which rely on some voluntary motor response to questions or other stimuli.

Both subjects participated in one session with mindBEAGLE. Data were collected from eight active EEG electrodes positioned according to the International 10-20 system, and vibrotactile stimulators were placed on the left wrist, right wrist, and the middle of the back. These vibrotactile stimulators generated sequences of brief vibrations to each of these locations, in sequence, at a ratio of 1:1:6. Before these vibration sequences began, subjects heard an auditory cue that said either “left” or “right”. This cue directed them to silently count vibrations to the left or right wrist. This “assessment” run showed clear event-related potentials (ERPs), including the P300, to target stimuli only. This result indicated that subjects were able to follow task instructions, including shifting attention from the left to right wrist across four trials within the run. Based on these real-time results, we concluded that both subjects did exhibit conscious awareness and could potentially communicate.

Next, each subject participated in multiple “communication” runs. These runs were identical to the “assessment” runs, except that subjects were not told where to focus their attention. Instead, the experimenter explained that counting stimuli to the left wrist would convey “yes”, whereas counting stimuli to the right wrist would convey “no”. Before each trial, the experimenter asked an autobiographical question that could be answered with yes or no. Both subjects were able to count stimuli to provide correct answers to the questions.

Thus, the mindBEAGLE system could be useful for assessing consciousness and providing basic communication for patients who cannot move or see. Additional work seeks to extend these promising initial results with more patients.

F43: Bilateral Motor Priming plus Task Specific Training for Severe Upper Limb Hemiparesis

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OBJECTIVES: 1) To examine the feasibility of an intense arm intervention study in older adults with severe chronic upper limb hemiparesis; and **2)** To explore the impact of bilateral motor priming (BMP) combined with a task specific training (TST) protocol on bimanual arm function; arm impairment; and persistence of transcallosal inhibition (TCI) from ipsi- to contralesional hemisphere.

Hypothesis 1: Both groups will improve from pre- to post-intervention on motor outcomes. At follow-up, the BMP+TST group will persist in their gains but HCE+TST will not.

Hypothesis 2: TCI will increase at post-treatment and follow-up in the BMP+TST but not in HCE+TST.

METHODS: Design: Parallel group single-blind (rater is blinded) feasibility trial using stratified randomization for group assignment. Stratification was based on impairment determined by Fugl-Meyer Upper Extremity (FMUE) score. **Subjects:** Fifteen individuals, 55 or older, at least 6 months post-stroke, who score between 23 and 38 on the FMUE. **Intervention:** Twice daily, subjects receive either: 1) 15 minutes of BMP via a low tech device (ExSurgeo Bilateral Priming Device); or 2) 15 minutes of training in healthcare education (HCE) on a computerized game using their affected hand. Following BMP or HCE, subjects receive TST for 45 minutes. Subjects receive 30 hours of the experimental (BMP + TST) or active comparator (HCE + TST) intervention. **Assessments:** Feasibility was assessed through recruitment and retention. Bilateral motor function was measured by The Chedoke Arm Hand Activity Inventory (CAHAI), while motor impairment was measured by the FMUE. Persistence of TCI was assessed via the ipsilateral silent period. All measures were administered at pre-/ post-intervention and follow-up (6 wks. post-treatment cessation).

RESULTS: Fifteen subjects completed the intervention, and one subject was lost to follow-up. Both groups improved on the CAHAI from pre- to post-intervention. However, the BMP+TST group (but not HCE+TST) continued to improve after the training ceased and exceeded the clinically important difference (as reported by Page et al, 2012) at follow-up. Persistence of TCI from ipsi- to contralesional increased at post-intervention in the BMP group but not the HCE+TST. An increase in TCI from ipsi- to contralesional hemisphere is a positive sign indicating more normalized inhibition.

DISCUSSION: It is feasible for older adults with chronic hemiparesis to participate in an intensive upper limb intervention. Consistent with previous studies (Stinear et al 2008; Shiner et al, 2014), between group differences on the FMUE and CAHAI were most apparent at follow-up. The FMUE change score (follow-up - pre) for HCE+TST was 2.25 while the BMP+TST change was 10 points, the largest between group difference we have seen in chronic subjects. There is no demonstrated effective treatment for individuals with severe chronic upper limb hemiparesis. It is important to identify treatments for this underserved and under-investigated population.

F44: Using neuroimaging to study the impact of motivation on brain activity during motor learning: Methodological considerations

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The effectiveness of motor rehabilitation after brain injury is variable, with some evidence implicating learner motivation as a key factor. It has previously been shown that motor learning is facilitated by motivational instructions that enhance expectations of learner's performance compared to a control group that receives neutral instructions prior to practice. However, little is known about the fundamental neural processes mediating the impact of motivation on motor behavior. Furthermore, experimental designs and motor learning tasks that can be performed in an imaging scan to study motivation are not well developed.

In this study, we tested a within-subject imaging design embedded within a classic performance-learning paradigm to examine short-term effects of a form of motivation, enhanced self-efficacy expectation, on brain activity and concurrent motor performance. Learning is assessed the next day using retention tests. Behavioral results from pilot work, conducted in the mock scanner without brain imaging to verify motor behavior findings, are presented here.

Twenty non-disabled young adults participate in a practice session and perform a finger pinch force tracking task, in which participants compress a pneumatic pad to keep a cursor inside a moving target for as long as possible in a 12-second trial. Prior to practice, participants are familiarized with the task to minimize non-specific learning effects. The practice session includes 2 conditions using 2 different spatiotemporal tracking patterns of equivalent difficulty. Participants practice following a neutral instruction (control) and an enhanced self-efficacy expectation instruction (motivation) comprised of 45 trials per condition. Time on target feedback is provided after each trial followed by a 12-second rest. Participants return the next day for no feedback retention tests. Motor performance is evaluated at retention as a measure of learning. Task-specific self-efficacy is assessed using a questionnaire, administered before and after each practice condition and before retention. Motor learning and self-efficacy will be compared between the experimental and control conditions.

Pilot behavioral data (n=5) conducted in the mock scanner show improved self-efficacy and task performance with practice. However, there did not appear to be any differential effects of the enhanced expectancy as measured by motor learning and self-efficacy between the two practice conditions. We found this within-subject design to be inadequate in replicating the improved motor learning effect of enhanced expectation demonstrated by previous between-group designs. Previous experience with the task, inherent in a within-subject design, may attenuate the effect of the motivational instruction on motor learning and self-efficacy.

On-going studies will test the effect of using two distinct motor tasks (i.e. Tracking task and pursuit rotor task) for the two experimental conditions to identify the behavioral findings before conducting the imaging study. This research paradigm may advance translational research to further our understanding of motivation in the context of neurorehabilitation.

F45: Postural control and Freezing of Gait in Parkinson's disease

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BACKGROUND AND AIM: The relationship between freezing of gait (FOG) and postural instability in Parkinson's disease (PD) is not clear. We analyzed the impact of FOG on postural control.

METHODS: 31 PD patients with FOG (PD+FOG), 27 PD patients without FOG (PD-FOG) and 22 healthy control (HC) were included and assessed in the ON state of medication. Postural control was measured with the Fullerton Advanced Balance (FAB) scale and with center of pressure (COP) analysis during quiet stance and maximal voluntary forward and backward leaning.

RESULTS: The groups were well matched concerning age, disease duration and disease severity. PD+FOG had significantly worse scores at the FAB scale (21.8 points, SD ± 5.8) in comparison to PD-FOG (25.6 points, SD ± 5.0) and HC (34.9 points, ± SD 2.4) ($p<0.01$). During quiet stance the average anterior-posterior COP position was significantly displaced towards posterior in PD+FOG in comparison to PD-FOG and HC ($p<0.05$). The COP position in the anterior-posterior orientation correlated with the severity of FOG ($p<0.01$). PD+FOG and PD-FOG did not differ in average COP sway excursion, sway velocity, sway regularity and postural control asymmetry.

CONCLUSIONS: Our results show that PD+FOG have reduced postural control in comparison to PD-FOG and HC. The COP shift towards posterior during quiet stance in PD+FOG leads to a restricted precondition to generate forward progression during gait initiation. The difference in COP position in PD+FOG patients may contribute to the occurrence of FOG or might be an altered stance position as a compensatory strategy to avoid forward falls.

F47: Neural correlates of freezing of gait in Parkinson's disease

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Freezing of gait (FoG) is an episodic, transient inability to initiate or maintain stepping that often accompanies advanced Parkinson's disease (PD). Recent studies have shown that structural and functional abnormalities in the supplementary motor area (SMA) are related to FoG in PD. The main objective of this study is to assess the role of SMA in Parkinsonian FoG by: 1) investigating functional communication between SMA and other neuronal networks; and 2) to relate the neuroimaging results to behavioral measures of FoG. Resting state functional imaging was obtained for 39 patients with PD [18 with FoG (age: 67.3±6.2 yr) and 21 without FoG (age: 70.0±6.6 yr)] in the off-medication stage, and 19 healthy controls (age: 72.8±8.1 yr). The center of the ROI of SMA was defined as x = -6, y =-8, z =58 (MNI coordinates). Our preliminary analysis demonstrates that all patients with PD (both with and without FoG) have significantly reduced ($p<0.05$) functional connections between the SMA and multiple regions within the motor network (including primary motor and somatosensory motor cortices) compared to healthy controls. Further, PD patients with FoG have increased functional connectivity between SMA and medial temporal regions within the ventral attention network compared to those without FoG. Detailed neuroimaging findings and their association(s) with objective and clinical metrics of mobility and cognition will be presented at the congress.

F48: A Novel Model of Lacunar Stroke Targeting the Forelimb Representation of The Internal Capsule in Rats

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Lacunar strokes of the internal capsule are common, and they can cause substantial and lasting impairment, particularly in hand function. Current rat models of internal capsule stroke can produce focal lesions, but the portion of the internal capsule that is lesioned can vary due to anatomical differences between animals. We describe the organization of the internal capsule in the rat and a technique to specifically target the forelimb representation. To our knowledge, the somatotopy of the internal capsule in the rat has only been described with anatomical techniques. To better characterize the somatotopy, we performed electrophysiological motor mapping of the rat internal capsule in addition to tracing fibers emanating from the forelimb and hindlimb motor cortex. For mapping, we used a microelectrode to stimulate the internal capsule and characterized the responses as forelimb, hindlimb, or both. From both anatomy and physiology, we found largely separate representations of the forelimb and hindlimb. To ablate the forelimb fibers, we adopted the Rose Bengal photothrombotic technique. The key innovation is the use of an optrode, which is a sharp electrode and an optical fiber glued together, with a total width of 200 microns. The electrode is used to stimulate the internal capsule and determine the “hot spot” of the forelimb representation, and the adjacent optic fiber used to deliver green wavelength light to activate the Rose Bengal. The duration of the light exposure was adjusted to produce a highly localized lesion. Rats had strong impairments in forelimb function, as measured by a pasta manipulation task. Our novel approach allows us to investigate changes in adjacent neural circuits after selective ablation of the forelimb representation. In sum, with this new approach we can achieve reproducible anatomical, physiological and behavioral changes that enable us to test hypotheses about how the corticospinal system adapts to lacunar stroke.

F49: Can prolonged exercise increase corticospinal excitability in chronic stroke survivors? *A pilot study*

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Background: Currently, a need exists to improve stroke rehabilitation programs to recover lost motor function. It has been suggested that prolonged exercise may enhance neuroplasticity and corticospinal excitability of individuals post stroke. Transcranial magnetic stimulation (TMS) offers a method to determine changes in neuroplasticity by examining the integrity of motor pathways.

Methods: Patients (n=5) who had suffered either a haemorrhagic or ischemic stroke at least 6 months prior to the study were recruited. The participants underwent a 10-week intervention; with exercise at 60% of their age predicted max heart rate 3 days/week. TMS was performed before and after the 10-week period, taking measures before and after the exercise session. TMS (Magstim 200; Magstim, Dyfed, UK) was conducted using a figure eight coil (with Brainsight NeuroNavigation; Rogue Research Inc., Canada) placed at approximately a 45° angle over the motor cortex. Upon stimulation, motor evoked potentials were recorded in the first dorsal intercostal muscle on each hand.

Results: In the 5 participants (age=65.0 years ± 6.44; 2 male/3 female), resting motor threshold (RMT) did not change in the affected limb and slightly decreased 0.5% in the non-affected hand from pre to post exercise at baseline. After the 10-week intervention, RMT decreased an average of 2.2% for the affected limb and decreased 1.2% from pre to post exercise.

Conclusion: These preliminary findings suggest that prolonged exercise increases excitability in chronic stroke survivors more so in the affected hemisphere compared to the non-affected hemisphere.