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Poster 1

Effect of Prism Adaptation Treatment on Reading Performance in Right-Brain Stroke Survivors

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Spatial neglect is a common disorder following unilateral brain injury such as a stroke. After right-brain damage, patients with spatial neglect typically show symptoms in the egocentric frame of reference. Some patients also manifest bias in the allocentric frame of reference. A recent study (Gossmann et al., 2013, Neurorehabilitation and Neural Repair) suggests that prism adaptation treatment (PAT) selectively improves egocentric but not allocentric bias in a cancellation test. In the present study, we examined whether this selective effect can be replicated in a reading task.

We studied reading performance in 25 patients (6 females) with spatial neglect. Patients were on average 69.3 years old (SD = 10.7) and 23.1 days post stroke (SD = 12.2) at the time of baseline evaluation. Patients read a 3-column article and a 2-page food menu (both subtests from the Behavioral Inattention Test). Over the course of the study, patients alternately read two versions of articles and menus seven times: prior to PAT (baseline), after one week of PAT, after two weeks of PAT, and weekly after PAT for 4 weeks. At baseline, there were more errors on the left column of the article and on the left page of the menu, consistent with egocentric neglect. In addition, within each column or page, the error rate was greater on the left half than the right. Interestingly, there were interactions between egocentric and allocentric bias such that the allocentric bias was greater in the right column of the article and in the right page of the menu. Over the course of the study, there was improvement in both article and menu readings (i.e., error rates reduced over time). 25% of the participants reached the normal range in reading performance after PAT. However, the degree of left-right asymmetry did not change in either egocentric or allocentric reference frames.

Consistent with the literature, our findings suggest that PAT has a therapeutic effect on reading. Inconsistent with the previous study, PAT does not always improve egocentric bias when assessed in a reading task. This pattern of results supports the view that PAT reduces lateralized errors in activities involving motor/manual components, but PAT may not improve left-right asymmetric performance in activities such as reading.

Poster 2

Activity of the Action Observation Network with Lower Extremity Use in Chronic Stroke Participants

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Neurorehabilitation after stroke, composed of physical and occupational therapy, can be a difficult process for patients, requiring time, energy, and effort. Studies suggest that action observation (AO) therapy may be modestly effective in improving motor ability after stroke. The Action Observation Network (AON), including the posterior inferiofrontal gyrus, rostral inferiopartietal lobule, and posterior superior temporal sulcus, may be implicated in AO therapy. In this study, we aim to investigate if a lower extremity effector (foot) can recruit regions of the AON, measured via functional magnetic resonance imaging (fMRI), during certain conditions of observing an action, imitating an action, and/or executing an action. Actions were composed of plantar flexion, heel rotation, and abduction or adduction similar to pressing on a gas pedal at an angle. These actions were shown as videos or photos to chronic (> 3 months) mild-to-moderately affected left middle cerebral artery stroke (n=16) and non-disabled control (n=13) participants. While watching these videos on a projector, both groups of participants were instructed to observe, imitate, or execute the shown action(s) to the best of their ability. We hypothesize that the non-disabled controls will recruit regions of the AON and that stroke participants will also recruit similar brain regions, yet this activity will be modulated by their degree of motor ability, measured by the Fugl-Meyer Exam. Preliminary results confirm that, the AON is recruited in non-disabled controls during conditions of observation, imitation, and execution of lower extremity movements, however, to differing degrees. Activity in the AON for participants with hemiparesis resembles these patterns from non-disabled controls, yet it is modulated by motor capability. Understanding which conditions and/or effectors engage the AON may help in determining types of conditions or effectors that are best used for AO therapy. This is an ongoing study and further analysis is needed to understand potential, if any, application of this technique to neurorehabilitation.

Poster 3

An iPod-based dual-task test for differentiating freezers and non-freezers in Parkinson's disease

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Background: People living with Parkinson's disease (PD) often show impaired motor performance under dual tasking (DT) conditions. For example, the addition of a cognitive load during walking can be particularly problematic, for PD freezers as it can lead to freezing of gait or even loss of balance. Given its impact on gait, safe ambulation, and fall risk, combined motor and cognitive rehabilitation is becoming an increasingly important area of research. Current DT and walking tests, however, are often impractical to implement during clinical visits due to the lack of required resources, e.g. long unobstructed walkways needed to complete cognitive-motor assessment or expensive specialised motion-capture equipment. The aim of this study was to investigate whether stepping-in-place (SIP) can be used to replace walking in testing DT influence on motor performance.

Methods: We tested SIP dual tasks (SIP-DTs) using iPod Touch technology and the GaitReminder (GR) application. The GR application delivers auditory instructions while at the same time allowing the monitoring, recording, and logging of step height (SH) measurements. A

total of n=30 subjects (n=14 PD non-freezers, n=10 PD freezers, and n=6 controls) were evaluated while maintaining and regular medication schedule on SIP and four SIP-DTs in this study (immediate-word-recall, serial 7 subtractions, serial 5 subtractions, and delayed-word-recall). Freezers and non-freezers were defined by the Freezing of Gait Questionnaire (FOG-Q) question #3.

Results: We found that while there was a general trend of reduced SH for all PD subjects relative to controls, the serial subtraction-7 SIP-DT was the only reliable SIP-DT at revealing differences between the groups. PD freezers exhibited significantly reduced SH relative to both controls and non-freezers during this SIP-DT ($p<0.05$). Receiver operating characteristic (ROC) analysis also revealed that an average SH cut-off of 3.7 cm during the serial 7 subtractions SIP-DT provided optimal sensitivity and specificity to distinguish between PD freezers and non-freezers, approaching 70% and 93% respectively ($p<0.05$).

Conclusion: The serial subtract-7 SIP-DT is an effective approach for evaluating DT in PD. Moreover, the serial subtract-7 SIP-DT can be completed within minutes, and unlike other DT tests, requires little space. Finally, the serial-subtract-7 SIP-DT and GR application provide an objective measure to identify PD freezers and non-freezers that, unlike other approaches, allows patients to maintain a regular medication schedule. These findings suggest that the serial subtraction-7 SIP-DT may be a useful clinical tool for developing rehabilitation-like programs for reducing the negative impacts of DT.

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Poster 4

Cognitive Processing Speed, Mood, and Fatigue Improvements in Persons with Multiple Sclerosis Treated with Dalfampridine

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Background: Problems with cognition, mood and fatigue are prevalent in persons with multiple sclerosis (pwMS). Dalfampridine extended release 10 mg tablet (D-ER), a potassium channel blocking agent used by clinicians to improve walking speed in pwMS, may have additional benefits. Changes in cognition, mood and fatigue are not typically monitored in persons taking D-ER. Little knowledge exists to support the use of cognitive, mood and fatigue assessments to evaluate response to D-ER in pwMS in a clinical setting.

Objectives: The objective was to evaluate the potential association of D-ER with changes in cognition, mood and fatigue in pwMS, using feasible, clinic assessments.

Methods: PwMS newly prescribed D-ER for routine clinical care were invited to participate in this investigator initiated prospective, observational study. Participants were monitored immediately prior to starting D-ER (baseline) and over the course of 14 weeks. Data presented are a subset of a broader observational study. Fifty-two participants were enrolled and 39 completed the 14 week assessment meeting criteria for analysis. Change in performance measures including the Symbol Digit Modalities Test (SDMT), Center for Epidemiologic Studies Depression Scale (CES-D) and the Performance Scale subscales of cognition (PS-C), mood (PS-M), and fatigue (PS-F) was analyzed using the Wilcoxon signed-rank test. A p-value of 0.05 or lower was considered significant.

Results: Consistent with the prevalence of MS, our sample was mostly female (79.5%). Changes observed from baseline to week 14 (n=39) showed improvement in measures of cognition (SDMT p=.002) and fatigue (PS-F p=.004). A 9.5% (+/- 15.2%) improvement was observed in SDMT scores. Cognitive processing speed improved in 66.7% of the participants on D-ER for 14 weeks. Significant improvement from baseline to 14 weeks was observed among participants with a baseline rating of moderate impairment in self-identified domains of cognition (PS-C p=.007), fatigue (PS-F p<.001) and mood (PS-M p=.034).

Conclusions: The results of the current observational study suggest that D-ER may improve cognition, mood and fatigue in pwMS and should be further studied in a controlled trial. In addition, our findings support the use of standardized assessments (SDMT, PS-M and PS-F) to monitor changes in cognition, mood and fatigue in persons treated with D-ER in a clinical setting.

Disclosure: This investigator initiated study was partially funded by Acorda Therapeutics, Inc. and the Mount Sinai Rehabilitation Hospital, Hartford, CT. Dr. Lo has served on advisory boards for Acorda Therapeutics, Inc.

Poster 5

Reliability and validity of a new forward reach assessment tool in a sample of healthy controls

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Background: Assessment of functional performance is important in guiding treatment and measuring progress in rehabilitation. Given the abundance of available outcome measures and the intense time constraints placed on therapists, those which are quick to administer, simple, reliable and valid have become popular amongst clinicians. The functional reach test (FRT) is commonly utilized and has been shown to be predictive of falls in elderly men, change in balance over time, and a reliable measure of balance in persons with multiple sclerosis (MS) with mild disability, Parkinson's disease, stroke, diabetes and the elderly. Individuals with increased sway and impaired limits of stability experience increased difficulty maintaining the maximum forward reach position. Such individuals challenge the evaluator's ability to accurately and consistently mark the true distance reached. The authors believe this to be a possible source of measurement error and variability discussed by Tyson et al. A new instrumented version of FRT, the Forward Reach Test Tool (FRTT) was developed to improve the accuracy and ease of use of capturing the FR on individuals with impaired balance. The reliability and validity of this new instrumented FRTT has yet to be assessed.

Objective: The purpose of this study was to assess the reliability and concurrent validity of the FRTT compared to the gold standard, FRT during simultaneous measurement of forward reach in a population of healthy controls.

Methods: Thirty nine healthy controls were enrolled and all data were collected during a single visit. Forward reach distance was measured using two different assessment tools, the traditional manual FRT and the new instrumented FRTT. Subjects raised their arm and reach as far forward as possible. The difference reached equals the FRT. Simultaneously, the subject would reach forward pushing a horizontal plate with a BOSCH Distance Measurer attached. A digital display

indicates the total change in distance of the plate for the FRTT score. The test was repeated three times and the manual FR examiner was blinded to the distance recorded by the FRTT. Mean data from 3 trials were analyzed using an intraclass correlation (ICC) as well as Pearson product moment correlation. Alpha level was set at <0.05; SPSS ver. 18 was utilized for all analysis.

Results: The FRTT is correlated with the FRT (ICC=.96). Mean of 3 trials was found to have a strong, positive and significant relationship (r =.98*). Concurrent validity of the simultaneous measurements between the instrumented and manual FR was found to have a strong, positive and significant relationship (r =.98; p<.001).

Discussion: The FRTT is a reliable and valid measure of FR in a sample of healthy controls. Future research will assess feasibility and appropriateness of using the FRTT in persons with increased sway and fall risk.

Poster 6

A Pilot Randomized Trial Comparing Inter-session Scheduling of Biofeedback Results to Individuals with Chronic Pain: Influence on Psychological and Physical Function

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Chronic pain is an intractable condition estimated to affect more than a third of the US population. Multidimensional treatment for chronic pain often includes biofeedback therapy to assist in development of pain self-management skills. Acquisition of pain modifying strategies through biofeedback training results from learning to volitionally control a physiological signal, that is, psychomotor learning. Research on variables that influence psychomotor learning has examined the schedule for providing external feedback within a training session that is optimal for long-term retention of skill. The majority of these feedback-scheduling studies have supported a paradoxical relationship that scheduling methods that *reduce* the frequency at which external feedback is provided to a learner during training (acquisition phase) result in greater levels of skill in retention tests separated from acquisition. Based on this notion, the relative frequency of feedback provided in acquisition training, such as continuous visual feedback offered in biofeedback training, should be reduced as early as possible in acquisition to reduce the likelihood for dependence on external feedback to control the biological process. To assess this premise, it was the purpose of this study to conduct a randomized pilot study comparing two biofeedback schedules for encouraging retention of pain modification ability, and improvement in physical and psychological functioning in people with chronic pain.

Participants engaged in heart rate variability (HRV) biofeedback training for 9 sessions, and then were contacted after 3 months to collect follow-up information. Two groups were compared: The *Faded Feedback group* received a high relative frequency of HRV biofeedback early in acquisition, with the amount of biofeedback systematically reduced across sessions so that by the final training session, participants were attempting to control HRV without external feedback. In contrast, the *Full Feedback group* received HRV biofeedback continuously while attempting to control HRV across the acquisition phase. Participants were adult patients participating in individual outpatient cognitive behavioral therapy for pain management. Several measures were used to evaluate the impact of the biofeedback schedules: pain intensity, fear-avoidance beliefs, self-report physical functioning, and post-program use of biofeedback skills.

The Faded Feedback schedule, compared to Full Feedback schedule, resulted in greater use of biofeedback skills post-program, and improved pain intensity and fear-avoidance beliefs at the conclusion of biofeedback training and 3-months following training. No differences were noted between groups for physical functioning.

This pilot study provided evidence that reducing the frequency of external visual feedback given to the learner with chronic pain in biofeedback training was associated with several positive outcomes over an extended period of time following training. Thus, over-presentation of external feedback during biofeedback training can *inhibit* the ability of people with chronic pain to retain skill in the long-term. We will use these pilot results to plan a larger clinical trial.

Poster 7

Interhemispheric interactions between axial and proximal arm muscle representations of the primary motor cortex

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After a unilateral stroke, 30% of individuals have decreased arm function. One mechanism that can support recovery of the arm after stroke is the reorganisation of interhemispheric interactions. Most studies of these interactions, as well as rehabilitation strategies, focus on the hand. However, postural control of proximal arm and trunk muscles are essential to elicit purposeful arm movements. As such, cortical areas involved in the control of these movements are likely to also play a crucial role in recovery of arm after stroke. To date, little is known about the interhemispheric dialogue between cortical representations of proximal arm and axial muscles in M1 of the two hemispheres, and how they change after stroke. Hence, in this study we used two different transcranial magnetic stimulation (TMS) paradigms to compare interhemispheric interactions between axial and proximal arm muscles in healthy volunteers. In the first paradigm, we assessed the ipsilateral silent period (iSP) in right Anterior Deltoid (AD) and Erector spinae at L1 (ESL1) during right isometric shoulder flexion in 9 subjects. In this task, AD was an agonist and ESL1 a postural muscle. As a control, we also assessed the iSP in a distal hand muscle, the right First Dorsal Interosseous (FDI), during isometric abduction of the index. The iSP was elicited by stimulation of the motor cortex ipsilateral to the recorded muscles with current intensities of 130% of active motor threshold (AMT). We found that iSP could be clearly elicited in FDI and AD in 6 subjects, and in ESL1 in only 3 subjects. The iSPs area for FDI, AD and ESL1 were not significantly different from each other (respectively 67%; 71%; 67 % of baseline EMG). Ipsilateral motor evoked potential (iMEP) could also be evoked, mainly in ESL1. In the second part of this study, a paired pulse paradigm was used in 5 subjects performing either isometric index abduction (FDI targeted) or shoulder flexion (AD and ESL1 targeted) at 10% of the maximum voluntary contraction. During contraction, a conditioning stimulus (CS; 1.3AMT) was applied to M1 ipsilateral to the recorded muscles. Following a 10 ms delay, a test stimulus (TS; 1.2-1.3AMT) was applied to M1 of the other hemisphere. The CS decreased the amplitude of the MEP evoked by the TS in FDI (90% of test MEP) and AD (82%). Contrastingly, it increased the MEP in ESL1 (135%). Our preliminary results suggest that whereas distal and proximal arm muscles (FDI, AD) seem to primarily exert an interhemispheric inhibition on their homolog, stabilizing axial muscles may have more facilitatory interactions. Supported by The Sensorimotor rehabilitation research Team (SMRRT-CIHR)

Poster 8

Attitudes of clinicians towards spasticity assessment

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INTRODUCTION: One of the common impairments observed after neurological lesions, such as stroke, traumatic brain injury, or spinal cord

injury, is spasticity. Using an appropriate outcome measure for spasticity is of great importance to both quantify and qualify the severity and progression of spasticity over time in order to determine the effectiveness of therapeutic interventions. Despite the importance of using valid and reliable outcome measures in rehabilitation, the literature currently shows that clinicians are not using them regularly in clinical settings. The purpose of the present study is to gain a better understanding of the attitudes of occupational therapists (OTs) and physical therapists (PTs) towards spasticity assessment.

METHODS: Attitudes of clinicians towards spasticity assessment were investigated through a self-administered web-based questionnaire that was sent by e-mail to hundreds of OTs and PTs in Canada working with patients who have had a neurological lesion. This questionnaire was developed by 3 researchers and 1 PhD student, all of whom had clinical backgrounds. Six other therapists then participated in the validation of the questionnaire content. Modifications were made according to their comments and suggestions. The final questionnaire included questions about socio-demographics, work environment, patient characteristics, the factors influencing the use of standardized assessments, as well as questions about the use and the level of satisfaction with spasticity assessments.

RESULTS: A total of 317 participants (204 PTs/113 OTs) completed the questionnaire. Among these, 91.4% of respondents answered that using validated and reliable spasticity assessment is very or somewhat important. When participants were asked to indicate, among a list of 12 suggestions, which assessments they would use to evaluate spasticity in a typical neurological patient, an average of 4.5 spasticity assessments was selected per participant. The 5 most frequent answers were: 1) range of motion (96.7%), 2) clonus (83.5%), 3) Modified Ashworth Scale (75.5%), 4) deep tendon reflexes (61.7%), and 5) functional scales (59.9%).

Considering that the Modified Ashworth Scale (MAS) is the best-known outcome measures to clinically estimate spasticity, participants were asked to evaluate their level of satisfaction with the MAS. Among the participants who answered that they would use the MAS, 90.1% reported that they were satisfied or somewhat satisfied with this spasticity assessment.

DISCUSSION AND CONCLUSIONS: A large proportion of clinicians believe that using a validated and reliable assessment to evaluate spasticity is important. However, despite the presence of a consensus among researchers that its construct validity is questionable, the MAS remains one of the preferred scales for spasticity assessment currently used by clinicians in their daily practice.

Poster 9

Does task engagement level affect how we move?

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High subjective engagement level is consistently found when motor tasks are performed under virtual or augmented reality conditions. In previous work, attentional demand was greater during a reach task to a virtual target compared to a real target. More importantly, engagement level was generally higher in the more difficult virtual compared to the easier real target condition. This study investigated the impact of engagement level on movement strategy by comparing reach kinematics for those with low- or high-engagement ratings during virtual target (VT) and real target (RT) conditions.

Using a within-subject design, 15 participants (59-88 yrs old) performed reach movements to targets arranged in a circular 8-target pattern; there were 48 reaches per condition and each from standing and stepping. A Kinect™ camera positioned in front captured each reach; position data were resampled at 12Hz. Movement onset/offset was defined as the first time at which the tangential velocity of the wrist virtual marker was above/below 1 cm/s. Kinematic variables included movement time (MT), time to peak velocity (TTPV), and time after peak velocity (TAPV). Participants' self-assessed engagement to each condition was acquired using a 5-level Likert scale for a single item administered after reaching. Participants were categorized into low-, neutral- and high- engagement (E) groups based on scale scores.

Reaches from standing to VT for participants with high-E showed longer MT than those with low-E; the longer MT was attributed to longer TAPV. Interestingly, MT for reaches from stepping to VT were independent of engagement. However, in spite of similar MT, the high-E group demonstrated shorter TTPV and longer TAPV than the low-E group. For easier reaches to RT, there was no evidence that engagement level modulated any kinematic measure.

These findings provide indirect evidence that engagement level may impact movement strategy, but only for relatively difficult tasks. Reaches to RT were relatively easy (from open-ended post-interview); RT reaches exhibited a symmetric velocity profile suggestive of a default strategy regardless of engagement level. In contrast, during more challenging VT reaches, a high-E level was associated with slower movements and a prolonged homing-in phase. We speculate that high-E may harness more attentional resources toward goal achievement. These preliminary group level findings suggest an interaction between engagement level and task difficulty on movement strategy. Further analysis of individual-subject variability within engagement level groups is needed to confirm or refute the group level analysis.

Poster 10

Remote Limb Ischemic Conditioning Enhances Motor Learning

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Background: Rehabilitation following stroke is often unable to eliminate many of the impairments associated with neurological injury. Rehabilitation is dependent on cognitive and motor learning which guide nervous system reorganization in response to behavioral training. In order to optimize rehabilitation outcomes, it may be beneficial to "condition" the nervous system prior to training and establish an optimal physiological environment for learning. Conditioning the brain with a subinjurious hypoxic insult has been shown to induce systemic neuroprotective effects. Moreover, brief intermittent ischemia of the limb, referred to as remote limb ischemic conditioning (RLIC) has recently been shown to strengthen spared pathways to motoneurons and lead to improved motor recovery following neurological injury. The next critical step is to investigate whether RLIC can be harnessed to promote plasticity and facilitate learning.

Objective: The purpose of this study was to test if RLIC paired with motor and cognitive training results in greater improvements in performance and learning compared to sham conditioning paired with training, in neurologically-intact adults. We hypothesized that conditioning the nervous system with RLIC prior to training would facilitate the neurophysiological processes of learning, thus making training more efficient, more effective, and more long-lasting.

Methods: Eighteen adults participated in this nine-session, single-blind study. Following randomization and baseline motor and cognitive assessments, sessions one and two consisted of RLIC or sham conditioning, achieved via blood pressure cuff inflation on the non-dominant upper extremity. Following these two days of conditioning, subjects returned for 5 consecutive training sessions. During each training session, subjects underwent RLIC/sham conditioning followed immediately by 15 minutes of motor training on a standing balance task and 15 minutes of cognitive training on an associative recognition memory task. Posttest performance was assessed at the end of the fifth training session and at two follow-up visits 2 and 4 weeks after the fifth training session.

Results: Using repeated measures ANOVAs, we found that subjects in both groups demonstrated improved performance from pretest to posttests on motor and the cognitive tasks (main effect of time). Subjects who received RLIC showed significantly greater improvements in motor learning and better retention of these gains compared to

subjects who received sham conditioning (group x time interaction). Compared to sham conditioning, RLIC did not result in greater improvements in cognitive performance or retention.

Conclusions: Our findings suggest that remote limb ischemic conditioning enhances motor skill acquisition and retention in neurologically intact adults. Future research is needed to optimize conditioning parameters so that RLIC can be implemented in persons with motor deficits post-stroke to improve rehabilitation outcomes.

Poster 11

Overcoming hurdles towards maximally effective transcranial direct current stimulation

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Transcranial direct current stimulation (tDCS) literature shows mixed opinions on efficacy, which can be attributed to lack of universally agreed dose amplitude, duration and regimens individualized according to skull thickness, subcutaneous fat, skull defects, etc. It is noteworthy that tDCS charge densities that are safely used in animal studies are two orders of magnitude higher than those used in humans[1] (~4 C/cm^2 in animals[2] versus ~0.06 C/cm^2 in humans[3]). While tDCS commonly has minor adverse effects[4], low current amplitudes (≤2 mA) for short durations (≤30 min/session) are used to avoid temporary concerns like skin redness and irritation in select patients. Skin being the first contact point that transmits highest electric currents and fields, increased doses can result in severe skin reactions. Here we explain why such limitations have not been observed in animal studies. First, translational studies are performed in smaller animal models like rodents and cats, making absolute distance between electrodes, and therefore electrical path resistance, significantly lesser than that in humans. Second, human skin has higher resistance than other species[5] resulting in more conversion of electrical energy into heat and potentially consequent inflammation. Third, tDCS has been applied epicranially in select rodent studies bypassing skin resistance at anode[1,6], which cannot be implemented through non-invasive clinical trials. Some of these limitations can be overcome by improving electrical conductivity of electrode-body interface that is stable over the course of tDCS session. It is not uncommon for saline-soaked sponges to offer uneven conductivity as an electrode contact area because of gravity-driven pooling of saline and drying from physical squeezing. Silicon-based lubricant gels, e.g., ones used for ultrasound imaging, offer good contact but are not good electrical conductors. Also, Hydration of the skin is not a major factor determining conductivity of the skin by tDCS (unlike AC current) because capacitance, but not resistance/conductance, of the skin is a function of hydration[7]. Therefore, using high-salt gel electrodes[8] on scrubbed[9], moisturized[10] skin or other ways to improve conductivity[11] can ensure less skin injury with stronger intracranial electrical fields without neural injury[12].

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Poster 12

Development Of A Simple App For Stepping Height Measurements During Rehabilitation Training In Parkinson's Disease

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Background: Foot height relative to the ground is an important deterministic factor in the safety of everyday walking for seniors, as reduced ground clearance by the foot can lead to tripping and falls. In addition, scaled down movement sizes (hypokinesia) in Parkinson's disease (PD) may also lead to disturbances in gait initiation and freezing. However, unlike measurement of step length, measurement methods of step height are technologically more challenging. In this study we developed an iOS App, which utilizes hip rotation angles to calculate the height of foot lifting from the ground during stepping in place. We have verified the accuracy of the method using video analysis software in 24 PD subjects and further show that the App also has the capability to detect significant minimal detectable changes (MDC_{95}) following step height training.

Methods: GaitReminder (GR) is an iOS App developed for iPod Touch. The device was attached to a subject's impaired-side leg, just above the patellar top line with the use of a high-performance thigh-band. Subjects also wore headphones to receive auditory instructions from GR about starting and ending of repetitive stepping-in-place (SIP). Stepping data is locally auto-saved, archived, and encrypted before being sent to a central server. We used correlation, regression, and Bland-Altman analysis to quantify the strength and evaluate the agreement between the calculated GR step height (SH) and that determined by video analysis software during 20 seconds of SIP. Ethics approval was obtained from University Ethics Board for Human Research and informed written consent was obtained.

Results: We found a significant linear relationship between the GR SH data and that derived from video analysis ($r=0.95$, $r^2=0.90$; $p<0.05$). Bland-Altman analysis also revealed an average measurement difference of <1cm (standard deviation of <2cm) among these methods ($p>0.05$). In a sub-sample of subjects (n=13), SIP test-retest reliability was evaluated and found to be good across three trials (ICC=0.88; $p<0.05$). Two subjects also underwent rehabilitation training by using GR with a defined SH threshold for music playback, thus creating a contingency between instrumental behaviour for musical reward stimulation and anticipatory motor control. Following approximately four fifteen-minute training sessions (2/week), both subjects increased their SH by ≥10cm, which is above the calculated 6cm MDC_{95}.

Conclusion: Stepping height as an alternative measurement of hip flexion and foot clearance can be accurately measured using an iPod App with minimum space requirement. The technique can be useful for rehabilitation training and the evaluation of other conditions where hip flexion may be affected such as stroke and autism.

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Poster 13

Repetitive transcranial magnetic stimulation to modulate cortical excitability after stroke: effect of participant characteristics

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A stroke-induced change in interhemispheric interaction (IHI) may increase the inhibition from the non-lesioned hemisphere toward the lesioned hemisphere, thereby impeding recovery of the paretic extremities. One plausible method to improve functional recovery is to decrease the excitability of the non-lesioned hemisphere and restore IHI balance by applying low-frequency repetitive transcranial magnetic stimulation (rTMS). Although low-frequency rTMS has been demonstrated to be safe and feasible for individuals with stroke, its effectiveness in modulating the excitability of the non-lesioned hemisphere and improving paretic hand function has not been consistently reported. It is essential to understand the factors that may impact the efficacy of rTMS, such as TMS methodology and participant characteristics, in order to optimize its application in stroke rehabilitation. The purpose of this study was to explore the potential participant characteristic factors with our preliminary data. Ten individuals with sub-acute stroke received active and sham rTMS in two consecutive days with a counterbalanced order. In the active condition, 1-Hz rTMS was applied over the representation area of extensor digitorum communis in the non-lesioned primary motor cortex (M1) at 90% resting motor threshold for 25 minutes. The excitability of the non-lesioned M1 was measured before and after rTMS using resting motor evoked potential (MEP) amplitude. Participants were divided into two groups (responders and non-responders), based on their MEP changes following active rTMS. Participant characteristics, such as age, stroke duration, lesion location and initial hand function, as measured by upper extremity Fugl-Meyer assessment (UE-FMA), were compared between the two groups. Among the ten participants, three showed down-regulation of excitability following active rTMS and were categorized as responders. No significant difference in stroke duration, initial hand function and lesion location was found between responders and non-responders ($p>0.05$). The responders appeared to be younger than the non-responders with a borderline significance ($p=0.07$). Further analysis showed that age was significantly correlated with the amount of change in excitability ($r=0.85$, $p=0.02$), suggesting that the efficacy of inhibitory rTMS was greater in young participants than old participants. Our preliminary data suggests that the ability of rTMS to modulate brain excitability may be a function of age in stroke population. The findings attest to the further need to determine the subject-specific characteristics that would enable prediction of good outcome following rTMS.

Poster 14

Combining Theta Burst Stimulation with Reaching Practice in Individuals with Severe Post-Stroke Arm Impairment: Two Case Studies

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Chronic severe arm impairment after stroke is costly and can greatly impact quality of life. There are few validated treatment methods for improving arm function in those with severe impairment and existing approaches often have a low ratio of outcome to effort. For example, repetitive reaching practice often results in improved performance, even in stroke patients with relatively severe motor impairment; however, the amount of improvement is small compared to the amount of time and effort required. It may be possible to enhance the effects of practice by applying non-invasive brain stimulation, such as transcranial magnetic stimulation (TMS), prior to reaching practice to increase the excitability of brain areas that could contribute to proximal arm recovery. Preliminary work in our lab has suggested that dorsal premotor cortex (PMd) of the intact hemisphere may contribute to affected arm reaching to a greater degree than neighboring cortical areas. We aim to determine if upregulation of intact PMd could enhance the effects of reaching practice in persons with severe arm impairment after stroke. Here, we report the results of the first two participants. At the first visit, a double-pulse TMS disruption was applied over intact PMd during a reaching response time task. At the second visit, participants performed a reaching response time pre-test before receiving intermittent theta burst stimulation (iTBS) over intact PMd at 80% of the active motor threshold of primary motor cortex (20 trains of 10 TMS bursts delivered at 5 Hz with 8 seconds between each train). Immediately after stimulation, participants performed an intensive session of repetitive reaching practice followed by a reaching response time post-test. At the third and final visit, participants performed the reaching response time post-test followed by the TMS disruption test. iTBS and practice were well-tolerated by both participants. Participants 1 (P01) and 2 (P02) both showed improved reaching response time after iTBS + practice (P01 was 35% faster, P02 was 16% faster). Kinematic Improvements were also evident (hand path length (16% decrease for P01, 13% decrease for P02), maximum directional error (8% decrease for P02), initial directional error (12% decrease for P02) and number of movement units (50% decrease for P01, 55% decrease for P02)). Both participants also showed larger disruption effects after iTBS and practice suggesting greater recruitment of intact PMd during performance of reaching movements. In conclusion, these early results suggest that reaching practice preceded by iTBS to intact PMd could improve reaching performance in persons with severe arm impairment after stroke and may increase recruitment of intact PMd when performing affected arm reaching movements.

Poster 15

Using dual-task paradigms to detect motor learning effects in older adults after task-specific training: A feasibility study

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Background: Theories of motor learning predict that repetitive practice of a given task (i.e. task-specific training) reduces the amount of attention needed to complete that task, thereby improving the task's automaticity. Changes in automaticity can be measured experimentally under dual-task conditions where the motor task and a secondary task are performed concurrently. We have shown previously that dual-task paradigms are feasible for detecting motor learning effects in young and middle-aged adults, such that dual-task interference is lower after task-specific training compared to before. One's ability to dual task, however, tends to decline with advancing age, which may limit this approach's application to older populations.

Objective: The purpose of this study was to test whether a dual-task paradigm was feasible for detecting motor learning in older adults.

Methods: Fourteen older adults (age 77.8±4.9 years) without any confounding neuromuscular impairment were randomly assigned to a training or control group. The training group completed 150 trials (2,250 repetitions) of a simulated feeding task with their nondominant hand, whereas the control group did not. This training did *not* occur under dual-task conditions. Task performance (measured as trial time) was tested at pre- and post-test under dual-task conditions in which participants simultaneously performed an auditory discrimination task (measured as percent accuracy). Dual-task interference was defined as a decrement in motor or listening performance under such conditions, and we hypothesized that learning effects due to training (i.e. automaticity) would yield less interference at post-test compared to pre-test.

Results: Preliminary data supported this hypothesis, with faster trial times and higher listening accuracy at post-test in the training group only; no changes occurred from pre- to post-test in the control group.

Conclusions: These results suggest that dual-task paradigms may be useful in detecting motor learning in older adults.

Poster 16

Enhancing activation of object use information with transcranial direct current stimulation

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Limb apraxia is a disorder of complex skilled action not attributable to weakness, incoordination, or other elemental sensory or motor impairments. Although it has a significant negative impact on activities of daily living, a number of recent evidence-based reviews indicate that apraxia following stroke is amenable to rehabilitation. In this study we tested whether non-invasive brain stimulation (transcranial direct current stimulation; tDCS) could be used to enhance functioning within the brain regions responsible for object use in neurologically intact participants, with the goal of applying the results to apraxia rehabilitation in the future. We have previously shown that when looking for a target object in an array with 3 non-target objects, neurologically-intact controls looked at use-related non-target objects significantly more than at unrelated non-target objects, even though object use was irrelevant to the task. This finding indicates that action representations associated with object use may be incidentally activated during visual object processing. Activation of these use representations are temporally delayed in individuals with apraxia, with the slowing predicted by lesions to the inferior parietal and posterior temporal lobes. Based on this finding, in the present study we applied anodal tDCS to those regions to determine whether stimulation would speed use activation. Results showed that use activations were speeded with tDCS (relative to sham tDCS), especially when contextual cues for object use were weak. In addition, the time to complete the search task was speeded with tDCS relative to sham. We discuss these results in terms of a neuroanatomic model of object and action processing, and the potential for using tDCS for rehabilitation of apraxia.

Poster 17

Enhancing the mirror illusion with transcranial direct current stimulation

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The perceptual-motor system's estimate of the current arm position is strongly dependent on visual feedback. One compelling example of this phenomena is the mirror illusion (MI). To experience the MI, a participant places her arms on either side of a vertically-oriented mirror, with only the arm on the reflective side of the mirror being visible. When the mirror is placed midway between the two arms, the reflection of the visible arm (viewed in the mirror) appears to be in the same location as the arm behind the mirror. Thus, the MI setup creates a compelling illusion in which visual feedback about movement of the arm behind the mirror comes from movement of the visible arm. This false visual feedback from the MI has been shown, over multiple sessions, to reduce post-stroke movement deficits. During this "mirror therapy", the impaired limb benefits from the illusory visual feedback from the unimpaired limb. Thus, it is highly probable that over time the MI leads to changes in bilateral interactions between motor networks within the two hemispheres. We hypothesized that the MI would be affected when we modified interhemispheric interactions using transcranial direct current stimulation (tDCS). Specifically, we tested whether bilateral tDCS stimulation to the primary motor cortices (anode-right-cathode-left and anode-left-cathode-right) would modify the MI, as measured using a previously-developed method of objectively quantifying the strength of the MI (Holmes & Spence, 2005). In this method, participants make reaching movements with the unseen arm behind the mirror while viewing the reflection of the other arm. When an offset in the positions of the two limbs relative to the mirror is introduced, the effects of the mirror are manifested in the bias of the reflected arm's position reaching of the unseen arm. We found that active tDCS in the anode-right-cathode-left montage increased the magnitude of the MI relative to sham tDCS. We take these data as a promising indication that tDCS could improve the effect of mirror therapy in patients with hemiparesis.

Poster 18

Manual Asymmetry in motor skill learning

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Motor skill learning involves a process wherein one learns to synthesize novel movement capabilities in absence of perturbation such that they are able to perform and retain the movement skill with higher accuracy, consistency, efficiency, coordination and flexibility. Performance asymmetry has been reported in motor control and adaptation to kinematic and dynamic perturbations of goal-directed actions. In this study, we investigated asymmetry in acquisition and retention of a complex motor skill that requires speed and accuracy for optimal performance. Further, we examined if skill learning asymmetry is influenced by arm dominance. 6 right-handed (RH) and 6 left-handed (LH) adults practiced 2 distinct tracks during different sessions separated by 2-4 weeks. During separate sessions, participants practiced with their dominant (DOM) or non-dominant (NDM) arm in a pseudo-randomized order. Performance changes during practice were characterized by improvements in accuracy while practicing within prescribed movement time ranges. Learning was quantified by changes in the speed-accuracy tradeoff (SAT) function measured at baseline and a day after practice ended. There were no baseline differences in the SAT function between the DOM and NDM arms. All participants improved their performance with their DOM and NDM arms with practice. With practice, the RH participants demonstrated significantly higher improvements in the SAT function for the dominant compared to the non-dominant arm. We did not find significant differences between the two arms for the LH group. With the limited practice provided for a complex motor skill, right-handed individuals demonstrate dominant arm advantage for learning. Extended practice may be indicated for improving skill learning with the non-dominant arm in the RH individuals. In RH individuals, asymmetry in skill learning may likely be related to the hemispheric specialization effects reported for motor control.

Poster 19

Bimanual coordination for functional tasks in patients post-stroke

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Most, if not all activities of daily living, require some degree of collaboration between two hands. While unimanual functional measures are widely used in stroke rehabilitation research, little is known about how functional bimanual movements are affected in patients post-stroke. The aim of this study was to investigate the kinematics and coordination between two arms as patients with

stroke and age-matched controls performed symmetric and asymmetric functional bimanual activities. We hypothesized that patients with stroke will demonstrate significant deficits in asymmetric, but not symmetric functional bimanual tasks compared to age-matched controls. 6 patients with mild- to- moderate impairments (Fugl-Meyer 30-55) after unilateral stroke and 6 control participants participated in the study. Participants performed 20-trial block of each of the three tasks: (1) unimanual goal-directed task (UNI), (2) symmetrical bimanual task (BISYM) which comprised of picking a box using both hands, and (3) asymmetrical bimanual task (ASYM) which comprised of opening a drawer with their non-paretic hand and pressing a button with their paretic hand. Trajectories of each hand were recorded using a 3-D motion recording system with 2 electromagnetic sensors placed on the dorsum of each hand. Kinematic measures included: movement time (MT), maximal velocity (Vmax), directness of trajectory (DT) measured as trajectory/distance ratio. Bimanual coordination was characterized by the time delay between the two hands as they performed the task. Both controls and patients with stroke demonstrated strong spatial and temporal coordination while reaching the box during the BISYM task, but patients demonstrated significant deficits while picking up the box. While coupling the two arms using "in-phase" movements may help reaching; synergistic coordination necessary for picking up the box is impaired in patients post-stroke. For the ASYM task, controls demonstrated greater temporal coordination compared to the patients, with a significantly greater time-lag between the paretic and non-paretic hand ($p<0.05$). Importantly, time-lag between the two hands in patients with stroke did not correlate with the movement time of the paretic arm during the UNI task. Our preliminary results demonstrate a task-based dissociation in bimanual coordination in patients post-stroke. Patients demonstrate deficits in coordination between two arms during execution of an asymmetric and synergistic aspect of symmetric bimanual task. The deficient bimanual coordination in the ASYM condition was not strongly related to deficits in unimanual control. This likely suggests different control mechanisms for unimanual and bimanual control in patients post-stroke. In addition, this may also indicate (but yet to be empirically established) that unimanual skill practice may not always translate to bimanual skill performance in patients post-stroke.

Poster 20

MEG-based functional connectivity changes with motor imagery training: evidence for motor imagery as an acquired skill

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Motor imagery (MI) is a form of practice in which an individual mentally rehearses a motor task, facilitating skill acquisition in the absence of physical practice (Jeannerod, 1995). MI has many clinical applications, including brain-computer interface and stroke rehabilitation. Previous research suggests that skill acquisition via MI is facilitated by repetitive activation of brain regions in the sensorimotor network similar to that observed in motor execution (ME; Hetu, 2013). This activation is influenced by differences in one's ability to perform MI (Wei, 2010), suggesting that MI ability is an acquired skill. In fact, spatial activation patterns during MI become more similar to that of ME with training. These training-related changes in MI activation have yet to be investigated from a network connectivity perspective. In showing how MI training drives network changes, the current study further demonstrates that the ability to employ MI for skill acquisition is a learned skill. Non-disabled participants (N=10; 24.7 +/- 3.8 years) performed both ME and MI of a unilateral seven-sequence button press task over three days. Magnetoencephalography (MEG) was utilized to capture neural activity. Coherence-based functional connectivity analysis was examined between eighty cortical nodes in the beta frequency band (15-30 Hz) and a partial least squares analysis conducted to compare coherence-based functional connectivity between session 1 and 3 (McIntosh, 2004). Preliminary findings indicate that functional connectivity was altered as a function of session, with network composition differing ($p < 0.05$) from session 1 to 3. Network changes included more lateralized (ie. in the contralateral hemisphere) activity during MI with more similar patterns of activity observed between MI and ME across sessions. Taken together, the current results indicate that the brain network underlying MI changes with training, further indicating that MI itself is a learned skill. Future work will utilize graph theory (Rubinov, 2010) to quantify changes in network characteristics during MI training, and examine the amount of MI training necessary to effectively facilitate skill acquisition in the absence of physical practice.

Poster 21

Cortical patterns and functional recovery in chronic stroke patients by functional electrical stimulation

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Background: The clinical effects of functional electrical stimulation (FES) have been demonstrated in several studies. Although the possible peripheral mechanism is known, the neuronal mechanisms supporting the effects of FES are yet to be identified. Positron emission tomography (PET) can clearly reflect changes in corresponding functional areas of the brain during stimulus. We investigated the effect of FES on functional recovery of the hemiparetic leg and the related cortical activation patterns by using PET.

Methods: Three hemiparetic patients with chronic stroke (female: 2, cerebral infarction: 3, mean age: 57.6 ± 9.5 years, over 7 years after stroke) were enrolled in the study. Brain activity using H_2O^{15}-PET, three-dimensional gait analysis using Vicon NEXUS, muscle strengths of the quadriceps, iliopsoas, and tibialis anterior muscles, and Berg Balance Scale (BBS) were evaluated before and after 4 weeks of FES training. Three-dimensional H_2O^{15}-PET studies were performed in four sessions: rest, voluntary contraction only (Vol), electrical stimulation only (ES), and simultaneous voluntary and FES (Vol+ES) of the paralyzed side. The voluntary contraction task was a repetitive leg press exercise at 0.125 Hz on 10% load of maximal isokinetic strength. FES was performed with a two-channel portable electrical stimulator. The quadriceps on the paralyzed side were stimulated at a carrier frequency of 2000 Hz, burst frequency of 100 Hz, and duty ratio of 50%. The procedures were in compliance with the Declaration of Helsinki and was approved by the local ethics committee.

Results: Although patients 1 and 2 showed improved gait patterns, BBS, and muscle strengths of the quadriceps after the 4-week FES training, motor function did not improve in patient 3. Over- and expanded-activation of the contralateral primary motor cortex (MI), supplementary motor area (SMA), and primary sensory cortex (SI) during the Vol task was localized to the contralateral MI area in the

three patients. The ipsilateral MI and SMA activation during the Vol task decreased in patient 3. The brain activation during the Vol+ES task was extended to the contralateral SI when compared with that observed during the Vol task, both before and after FES training.

Conclusions: This study is the first to document that to perform cortical activation using PET during the same voluntary movement of the paretic leg before and after 4 weeks of FES training. The expanded bilateral motor-related areas before FES training were localized to the contralateral SMA and MI after FES training.

Poster 22

The Use of Body-Machine Interfaces to Examine Developmental Change in Motor Skill Acquisiton

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How does learning in children differ from that in adults? This issue has important implications both from a theoretical motor development standpoint as well as in pediatric rehabilitation. Addressing this question has methodological challenges because in typical motor tasks, any differences in learning strategies between children and adults are often confounded by differences in task familiarity and anthropometric changes.

In order to minimize these confounds, we investigated how children and adults acquire a novel motor skill in a virtual task using a body-machine interface (BoMI). A body-machine interface transforms body movement into the control of an external device. In addition to being a novel task, it allows tasks to be body scaled - thereby ensuring that both children and adults could perform the task using their existing movement abilities.

Participants learned to use their shoulder movements to control a computer cursor in a center-out reaching task to 8 different targets. Shoulder movements were measured using 4 inertial measurement units (IMU) attached to the participants' upper body and mapped to cursor position. Both children and adults practiced for a total of 160 trials toward 4 targets.

Results showed that initially in practice, children had longer movement times (~50%) compared to adults. This difference in movement time was also associated with a change in the movement strategy. The analysis of the task and null space variance showed that children tended to use greater exploration (i.e. greater task space and null space variance) when compared to adults initially in learning. However, by the end of practice, the performance and exploration for the two groups were similar.

These results suggest that children tend to use greater exploration initially in learning. Future studies will investigate how this difference in learning strategy may be exploited to facilitate motor learning in children.

Poster 23

Dissociating the mechanisms of savings and anterograde interference

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Motor learning forms the basis of movement rehabilitation. Better understanding of what contributes to the retention of motor learning is crucial to improving outcomes of movement rehabilitation. In motor adaptation learning, retention has been proposed to occur via (1) reinforcement, where repeating an adapted movement associates the adapted movement with rewarding outcomes; and (2) use-dependent plasticity, where repetition biases subsequent movements to be similar to the repeated movement. Retention is evident in savings, where initial learning improves subsequent learning, and anterograde interference, where initial learning impairs subsequent learning. Savings appears to rely on reinforcement mechanisms (Huang et al., 2011), as deficient reinforcement mechanisms in Parkinson's disease impairs savings despite intact initial learning (Leow et al., 2012). The mechanisms of anterograde interference remain unclear. We propose that use-dependent plasticity contributes to anterograde interference, but not to savings. This proposal was tested by limiting or extending movement repetition while stimulating the motor cortex with anodal transcranial direct current stimulation, which increases use-dependent plasticity when paired with movement repetition. Participants first adapted reaching movements to a counter-clockwise rotation of visual feedback imposed either abruptly (extended repetition) or gradually (limited repetition) in a first block, during which either sham or 2mA anodal transcranial direct current stimulation (tDCS) was applied over motor cortex. Anterograde interference was then assessed in a second block with a clockwise rotation, and savings was assessed in a third block with a counterclockwise rotation. We found that anodal M1 tDCS elicited more anterograde interference than sham stimulation with extended, but not with limited movement repetition. Conversely, anodal M1 tDCS did not affect savings with either limited or extended repetition of the adapted movement. Crucially, the effect of anodal M1 tDCS on anterograde interference did not require large errors evoked by abrupt perturbations. M1 tDCS still increased anterograde interference even with small errors evoked by a gradual perturbation when target manipulation enforced extended movement repetition. These findings demonstrate that use-dependent plasticity contributes to anterograde interference, but not to savings. This and previous work suggests dissociable mechanisms of savings and anterograde interference. Better understanding of the mechanisms underlying savings and anterograde interference allows for sensible manipulation of these mechanisms to optimize retention of rehabilitation gains in clinical practice.

Poster 24

Reduced Intracortical Inhibition is Associated with Bimanual Common and Dual Goal Tasks

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Objective: Stroke is the leading cause of long-term disability worldwide with approximately 75% of stroke survivors reporting functional upper extremity dysfunction. Many activities of daily living (ADL's) comprise upper extremity (UE) tasks involving varying degrees of collaboration between the two arms/hands. Some tasks involve a common goal in which the two hands share a single focus, such as picking up a box. Others involve separate goals, such as picking up two different items at the same time. We hypothesize that fundamentally different control mechanisms are involved in each of the two types of tasks, and that this will have important implications for the rehabilitation therapies administered to populations whose UE movement has been impaired. In this pilot we present preliminary results of testing to determine the intracortical inhibition and facilitation to upper extremity muscles during unimanual, bimanual common goal and bimanual separate goal isometric tasks in healthy subjects. Subjects: Six healthy right handed adults

Methods: Intracortical inhibition and facilitation (SICI, ICF) of the dominant hemisphere were assessed bilaterally for the biceps during three conditions; 1) unimanual isometric task, 2) bimanual common goal isometric task and, 3) bimanual dual goal isometric task. Results: In this preliminary data set, a significant reduction in SICI ($p < .05$) was found for both bimanual common goal tasks and bimanual dual goal tasks compared to the unimanual task condition. While SICI was reduced for bimanual common goals tasks compared to bimanual dual goal tasks it was not reach a significant difference. No significant differences were seen between task conditions for ICF.

Discussion: Reduced intracortical inhibition seen during the two bimanual tasks conditions is indicative of a disinhibitory mechanism, at least within the dominant hemisphere, underlying bimanual arm activation compared to unilateral arm activation. In this preliminary data set the two bimanual conditions did not differ in terms of intracortical inhibition. Further work will include increasing the sample size to see if this finding remains consistent and will include an exploration into interhemispheric inhibition to further determine the effects of these difference task conditions on interhemispheric interactions.

Conclusion: A reduction in SICI or disinhibition was seen during bimanual dual goal and common goal tasks when compared to unimanual task performance. This may have implications for consideration of training approaches for individuals following stroke.

Poster 25

Cortico-cortical coupling during bilateral forces

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Interhemispheric interactions between primary motor cortices play an important role in the control of bilateral forces. However, the mechanisms involved in the generation of bilateral isometric contractions of increasing force levels remain poorly understood. Here, we used coherence analysis between electroencephalographic (EEG) signals from the left and right primary motor cortices (EEG-EEG coherence) and the ipsilateral cortical silent period (iSP; a measure of interhemispheric inhibition) to examine the cortico-cortical coupling during bilateral forces. We tested healthy controls subjected during unilateral and bilateral isometric index finger abduction at 10, 40 and 70% of maximal voluntary contraction (MVC). EEG-EEG was calculated in the alpha (8-13 Hz), low (13-21 Hz) and high (21-30 Hz) beta frequency bands. We demonstrate that mean coherence decreased during increasing levels of force generation in all frequency bands. Whereas, the magnitude of the iSP increased with increasing levels of force. We found a significant inverse correlation between the magnitude of the iSP and EEG-EEG coherence in the high frequency band, particularly at low levels of force, suggesting an association between these measurements. Together, our results indicate cortico-cortical coupling during bilateral forces might involve oscillatory activity in the high beta frequency band.

Poster 26

Effects of Short-Term Cycling Exercise on Functional Measures of Aging Related Changes in Upper Extremity Function

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Aerobic fitness has long been associated with better upper extremity function (Spirduso, 1975), yet the neural changes largely responsible for these improvements are not well understood. It has been proposed that alteration of inhibitiory systems in the cortex have strong effect on plasticity in aging and regular aerobic exercise may be prophylactic in preventing aging-related changes in cortical inhibition (McGregor et al., 2013). In the current study, we enrolled sedentary older adults (60 years+) in a short-term (12-week) exercise program to explore if improvements in aerobic capacity alter upper extremity motor control. We evaluated changes in neural activity using functional magnetic resonance imaging and transcranial magnetic stimulation. Participants improved estimates of VO2max by 10-15% on average as a result of the aerobic exercise intervention. Preliminary results show behavioral improvements in both affective, cognitive and motor dexterity measures as a result of the exercise intervention. Pre/Post session TMS results indicate an increase in interhemispheric inhibition, though additional data analysis is required. Comparison of functional MRI datasets in conventional pre/post assessment did not show significant differences in interhemispheric communication. A network analysis approach to address systems change is warranted and may yield additional information from MRI datasets.

Poster 27

Home-based Mirror Therapy for Rehabilitation of Hemiparetic Lower Limb Post-Stroke: A Pilot Study

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Mirror therapy (MT) is a relatively new therapeutic intervention for hemiparesis. MT involves performing movements with the unimpaired limb while watching its mirror reflection superimposed over the (unseen) impaired limb, thus creating a visual illusion of enhanced movement capability of the impaired limb. While a growing body of clinical research indicates that upper limb MT benefits stroke patients to a degree comparable to or better than other therapies, only one study has demonstrated efficacy of lower limb MT in a subacute stroke population[1], and potential benefits in a chronic population are unknown. The aim of the study was to determine whether a home-based form of MT is an effective treatment for lower limb hemiparesis in chronic stroke survivors.

This study used a home-based MT regimen with a custom made MT device and a DVD providing instructions. The 30 minute training video directed participants to flex and extend the knee, dorsiflex and plantarflex the ankle, and circumduct the foot. Participants performed training at home two times per day, 5 days per week for four weeks. Seven individuals with chronic CVA and lower extremity paresis were enrolled; five completed all sessions. Outcome measures included lower extremity Fugl-Meyer scores (LE-FM); self-selected walking speed (SSWS) and fastest walking speed (FWS); and an accuracy index (AI) for an ankle tracking task, which was performed on both more affected (MA) and less affected (LA) limbs. This final measure used a custom designed apparatus to quantitatively assess voluntary control of ankle movement. All measures were collected during two baseline periods separated by at least 24 hours, during training (weekly assessments), immediately following training (post-treatment), and at 1-month follow-up.

We found that the AI on the more affected side improved significantly from baseline (pre-training) to post-training ($p<0.05$). AI on the less affected side and scores on the LE-FM trended towards, but did not reach, significance ($p = 0.07$). There were no significant changes in preferred walking speed ($p=0.67$) or fastest walking speed ($p=0.30$) from baseline to post-training; however, trends for improvement were noted at the 1-month follow-up.

Overall, we have identified some positive effects of MT, particularly on volitional control of the more affected ankle. MT may also contribute to improved walking speed over time. This pilot study is a first step towards establishing a home-based therapy for gait rehabilitation for stroke survivors, and may be especially beneficial for those who have limited access to other forms of rehabilitation.

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Poster 28

Diffusion tensor tractography study of sensorimotor pathways in unilateral hand amputees

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Background: Injury to the peripheral nerves, such as hand amputation, is associated by large-scale functional reorganization in sensory and motor cortices contralateral to the injury. Animal models indicate structural changes in the gray matter of these cortices as well as in other brain regions, such as thalamus, brainstem and the spinal cord. Evidence for activity-dependent changes in white matter integrity in animal models or humans is less clear. We used diffusion tensor imaging (DTI) to test the hypothesis that the chronic unilateral hand loss is associated with changes in structural integrity in major afferent (medial lemniscus, ML) and efferent (corticospinal tract, CST) pathways of the hemisphere contralateral to the amputation.

Methods: We tested 13 (3 female), right hand dominant, chronic (mean+SD=23+14years), traumatic unilateral, hand amputees (4 missing the left hand) and 13 age-, gender- and handedness matched controls. Single-shot spin-echo echo-planar DTI images were acquired (3T Siemens Allegra MRI scanner). Probabilistic tractography was used to delineate the ML and CST in each hemisphere (FMRIB Software Library software). A seed for the ML was defined anatomically at the brainstem level with a thalamic waypoint and cortical terminus. A seed for the CST was defined in the cerebral peduncle with a waypoint in the internal capsule and cortical terminus. Volume, mean diffusivity (MD), and fractional anisotropy (FA) were computed for the tracts of each hemisphere in both groups.

Results: We failed to detect any significant differences in tract volume, MD or FA of ML or CST between hemispheres in controls. By contrast, amputees exhibited significant asymmetries in both ML and CST contralateral to the amputation. Relative to the ipsilateral side, contralateral ML exhibited decrease in volume and increase in MD. FA was not significantly different between ipsi- and contralateral ML. Compared to ipsilateral CST, contralateral CST displayed decrease in FA and increase in MD. There were no significant between-hemisphere differences in CST volume.

Discussion: Our preliminary results suggested that the structural integrity of contralateral ML and CST is altered following unilateral amputation. Hand loss precipitates a major reduction in afferent signals and this may account for ML changes in MD and volume. Axonal degeneration could be a potential candidate for these changes. An extensive reorganization in the motor system has been also reported after hand loss and this might account for the asymmetry in CST FA and MD. The absence of changes in CST volume is consistent with the preservation of the descending outputs.

Poster 29

Classification of Normal and Abnormal Gait in Young Children Based on Foot Pressure Data: Towards Remote Monitoring of Medical Interventions

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Background and objective: During the implementation of a rehabilitation regimen it is crucial to use validated measurements in order to evaluate treatment effectiveness. The goal of this project was to demonstrate that it is feasible to apply computer vision technologies to develop a classification algorithm for normal/pathological gait in young children based on specific foot pressure features extracted from GAITRite acquisition files.

Methods: Walking data was collected form 95 healthy children aged 2-4, and from 10 subjects of the same age group with abnormal gait (toe-walking). After Gaussian data normalization, 22 features were extracted Using Principal Component Analysis (PCA); discriminative mapping methods were applied. Two classifiers (Support Vector Machines-SVM, and Random Forest-RF) were compared using a 5-fold cross validation.

Results: Use of a 4-class separation a recognition rate of 82.5% can be achieved for classification of normal versus pathologic gait. Combination of age and normal/pathologic data (6-class) improved the accuracy to 94.4% by SVM an to 97.5% by RF model.

Conclusion: Foot pressure data can be used for accurate classification of normal/pathologic gait in young children. Our model appears to be able to detect subtle differences in foot positioning suggesting a potential application for quantification of gait abnormality in very young children. A standardized and economic measure of gait would provide important feedback to clinicians regarding the effectiveness of rehabilitation interventions, allow for self-evaluation, and guide accurate treatment modifications.

Poster 30

Severe spondylosis presenting with anterior cervical osteophytes induced respiratory arrest and incomplete quadriplegia secondary to cervical spondylotic myelopathy: A rare case report

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Case Description: A 79 year old male presented to the Emergency Department for shortness of breath, hypoxemia, inspiratory stridor, and respiratory arrest. Consequently, he was intubated and mechanically ventilated. He was extubated uneventfully the following day without subsequent intubation.

Patient interview and records revealed six months of worsening lower extremity weakness, difficulty with gait and balance, three months of urinary incontinence, one or two months of hand weakness, and three or four weeks of dysphasia with both liquids and solids, hoarseness, and coughing with swallowing. Prior to the development of his symptoms, he ambulated with a walker.

On physical exam, the patient had bilateral thenar atrophy, right hand asterixis and claw-like stiffness, and an abnormal gait with spasticity. Motor examination revealed 2/5 finger extension bilaterally, 3+ biceps and triceps reflexes bilaterally, positive right ankle clonus, and bilateral Hoffman's sign. On sensory examination, touch, pinprick, temperature, and proprioception over toes, feet, and fingers were decreased. Fine motor movements were decreased bilaterally.

Neck CT myelogram demonstrated severe spinal stenosis at C5-C6 and large anterior cervical osteophytes from C3 - C6, compressing the esophagus and the hypopharyngeal airway at the level of the epiglottis. In addition, the patient had multilevel lumbar spondylosis with disc bulging and resultant multilevel central canal stenosis. Video swallows further suggested severe pharyngeal dysphagia secondary to large anterior cervical osteophytes.

The patient underwent anterior cervical decompression, which included removal of osteophytes from C3-C6 and discectomy and fusion at C5-C6.

Assessment/Results: After forty days of inpatient rehabilitation, the patient's oral intake improved. Upon discharge to sub-acute rehabilitiation, he tolerated a mechanically soft diet and nectar thick liquids with close staff supervision 3 times/day and PEG tube feedings during the night. He continued to experience weakness of upper and lower extremities. He uses a sliding board with assistance to transfer to his wheelchair and toilet. He has taken a few steps with therapy and has propelled his wheelchair 100 feet using upper extremities with close supervision. However, he requires moderate to maximal assistance to dress himself.

Discussion: To our knowledge, there was one documented case of respiratory arrest secondary to anterior cervical osteophytes in UK. The underlying condition, which causes a production of a significant high amount of osteophytes in this patient, is unclear. His severe spondylosis with anterior cervical osteophytes and cervical spondylotic myelopathy was detected late. Despite aggressive management, the patient's recovery has been very slow.

Conclusions: Degenerative changes of the cervical spine remain clinically silent until advanced stages. In any elderly patient with dysphagia, urinary incontinence, and loss of function in the upper and lower extremities, recognizing anterior cervical osteophytes and cervical myelopathy during early stages of disease is important due to life-threatening manifestations or severe disability.

Poster 31

Skill acquisition with the non-dominant hand and associated changes in functional connectivity between sensorimotor hand representations

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Unilateral impairment of the dominant right hand can arise from many causes, including diseases or injuries that affect the central or peripheral nervous systems. For some patients, this impairment may be irreversible, which forces them to compensate with the intact non-dominant left hand to perform movements that require high levels of precision. Therefore, there may be broad clinical significance to understanding the behavioral and neural changes involved in learning and retaining precision skills with the left non-dominant hand. We addressed this issue through a novel precision drawing task and resting-state functional connectivity MRI (fcMRI).

We trained 19 healthy right-handed adults (age 27 ± 8, 13 female) to perform a precision drawing task with their left hand. In this task, participants used a pen to draw continuous lines (45-180 mm) within provided boundaries (3, 4, or 5 mm tolerance); primary dependent measures included endpoint speed and smoothness. The training regime involved 10 days of left hand training, with a fixed number of training trials on each day (15-25 minutes). We tested participants' right hand performance before and after training. Participants returned for follow-up testing sessions 1 week, 1 month, and 6 months after the end of training. In addition, we identified training-correlated changes in functional connectivity with seed regions in bilateral hand sensorimotor cortex, via fcMRI before and after training.

Seventeen participants (89%) showed significantly improved left hand performance across training. The performance difference between hands decreased significantly in the smoothness domain. Despite discontinuation of left hand training, performance improvements remained stable over time: six months after training, 12/14 (86%) participants still showed significantly improved left hand performances.

We found a learning-correlated decrease in functional connectivity between right (trained) sensorimotor hand cortex and bilateral cortical areas including sensorimotor, premotor, and superior parietal cortex. These findings suggest that successful learning of precision skill with the left non-dominant hand may involve increased independence of the non-dominant from the dominant sensorimotor cortex when at rest. We speculate that these changes may be integral to compensation with the left hand, and thus support improved patient ability to perform activities of daily life after impairment of the right hand.

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Poster 32

Predicting variability of distal muscle recruitment curves in stroke using diffusion tensor imaging (DTI)

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Viability of corticospinal tracts (CST) has long been hypothesized to predict functional outcomes of upper limbs following lesions affecting the central nervous system, such as stroke or spinal cord injury. One highly utilized method for understanding CST viability, as a means of predicting and tracking longitudinal patient functional recovery, has been use of the non-invasive neurophysiologic technique transcranial magnetic stimulation (TMS). Specifically, within TMS, electromagnetic induction to the scalp overlying motor cortices (M1) results in an elicited contraction of the contralateral target muscle, termed motor evoked potentials (MEPs). In addition, MEP recruitment curves (RCs) are also determined by assessing MEP amplitudes at incremental stimulus intensities until a MEP plateau is reached. MEP amplitude and the area under the recruitment curve are believed to represent the gain or viability of descending CST to the target muscle and are utilized to track patient recovery. Unfortunately, however, within any patient population, MEPs are highly variable compromising measurement of RC at incremental intensities. Here, in a sample population of stroke patients we investigated whether the extreme variability of RCs can be ascribed to poor white matter integrity of in the CST, as measured by diffusion tensor imaging (DTI). As a metric of overall tract integrity, fractional anisotropy (FA) was compared between the lesioned and non-lesioned hemispheres for tracts projecting between the posterior limb of internal capsule (PLIC) and major cortices including: M1, premotor cortex (PMC) and supplementary motor area (SMA). FA was evaluated at 3 levels: (1) single-slice at the PLIC, (2) weighted average along the length of the tract and (3) segment of tract lying within the stroke/degenerated region. Notably, we found that variability in RCs was strongly correlated with segmental variations of FA for tracts converging from M1 ($R=-0.766$, $p<0.027$), PMC ($R=-0.647$, $p<0.083$) and SMA ($R=-0.673$, $p<0.067$). In addition, we found that RC variability was significantly predicted by segmental variation of FA along tracts emerging from M1 ($B=-0.766$, $p<0.027$). Collectively, our results suggest that of the three investigated types of DTI analysis, segmental FA values may provide the strongest clinical sensitivity in predicting variations in MEP generation in distal muscles. In addition, by reconstructing tracts to three major cortices, future work can now begin to predict recovery potential based on the viability of individual CSTs. Finally, by isolating potential sources for variability in of MEP measurement, we hope to further improve the diagnostic ability of TMS.

Poster 33

Increasing Repertoire of Finger Movements to Improve Hand Dexterity in Stroke

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Stroke often results in impaired hand function that significantly impacts the ability to perform activities of daily living. Hence there is a need to discover new techniques to improve hand dexterity. Here, we examine the use of a body-machine interface to induce reorganization and increase the repertoire of finger movements in stroke.

8 individuals with chronic stroke (average 6 years post-stroke) were recruited for the study. Participants wore a Cyberglove and the signals corresponding to flexion/extension of the MCP joint of the four digits were mapped linearly on to the position of a cursor on the screen. The task was to move the cursor back and forth between two targets positioned at the left and right edges of the screen.

In order to facilitate exploration of different finger movements, we gradually changed the weightings in the map between the finger movements and the movement of the cursor. For example, the weights of the index, middle, ring, and little fingers (I,M,R,L) were initially set to (1,1,1,1) - which requires a power-grasp pattern. This weights would be gradually changed during the course of the trial to (1,1,-1-1) - which requires individuation between the IM and RL fingers. Each trial consisted of between 50 and 100 targets, and participants practiced the task for 4 sessions spread over two weeks. We measured the repertoire of finger movements generated in these trials using a principal component (PCA) analysis.

Results showed that participants were able to reorganize their finger coordination patterns to adapt to the changing weights and reach the targets. Moreover, in 6 out of 8 subjects, the variance accounted for by the first PC (which indicated the dominant coordination pattern) decreased with practice (on average from 82 to 77%), indicating that participants were able to expand their repertoire of finger movements.

These results suggest that the use of a body-machine interface resulted in increasing the repetoire of finger movements in stroke survivors. This technique provides insight into designing a rehabilitation paradigm targeted at breaking maladaptive synergies.

Poster 34

Efficacy and feasibility of functional upper extremity task-specific training for older adults

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Background: Although functional task-specific training is a viable approach for upper extremity neurorehabilitation, its appropriateness for older populations is unclear. If task-specific training is to be prescribed to older adults, it must be efficacious and feasible, even in patients with cognitive deficits.

Objective: This cross-sectional study tested the efficacy and feasibility of upper extremity task-specific training in older adults.

Methods: Fifty older adults (age 65-89 years) without any confounding neuromuscular impairment were randomly assigned to a training group or no-training control group. The training group completed three days (2,250 repetitions) of a simulated feeding task with their nondominant hand; the control group did not. Both groups' task performance (measured as trial time) was tested at pre- and post-test, and the training group was re-tested one month later. Efficacy was determined by rate, amount, and retention of training-related improvement, and compared across levels of cognitive status. Feasibility was determined by participants' tolerance of the prescribed training dose.

Results: The training group was able to complete the training dose without adverse responses, and showed a significant rate, amount, and retention of improvement compared to the control group. Cognitive status did not alter results, although participants with lower MoCA scores were more bradykinetic overall.

Conclusions: Task-specific training may be appropriate for upper extremity neurorehabilitation in a wide range of older adults, regardless of cognitive status.

Poster 35

Learning, retention, and inter-limb transfer of a novel gait training paradigm

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Previous research indicates that motor learning is a key component of recovery after neurological injuries such as stroke or spinal cord injury. We recently developed a novel functional motor learning paradigm for gait rehabilitation; however, little is known on the retention and inter-limb transfer effects of our paradigm. Therefore, the purpose of this study was to evaluate the consolidation and inter-limb transfer effects of our leg motor skill-learning task in a group of neurologically intact adults. A secondary purpose was to evaluate whether transfer effects are side-specific as upper-extremity literature indicates that spatial accuracy tasks are learned better when practiced initially with the non-dominant hand. Twenty-five young adults (13 right-group and 12 left-group) were tested on two consecutive days. Participants performed a target-tracking task that necessitated hip and knee flexion modifications while walking on a treadmill. On Day 1, the right-group performed testing on the right leg. On Day 2, the subjects were tested for right leg retention and left leg transfer effects using the same paradigm. The left group performed the same sequence beginning on the left leg. Changes in tracking error were computed to study the learning, retention, and transfer effects. The results indicated that repeated practice of the leg motor learning task resulted in significant reduction in target-tracking error in both the groups ($P<0.05$). Subjects in both groups retained their performance similar to those observed at the end of training on Day 1 (Day 1, Block 10 Tracking Error = 12.7 ± 0.5%; Day 2, Block 1 Tracking Error = 13.1 ± 0.9%, $P>0.05$). Similarly, both groups displayed transfer effects between legs ($P<0.05$) and the inter-limb transfer appeared to be symmetrical between legs ($P>0.05$). To address whether the transfer effect was mediated due to consolidation or due to practice of target-tracking prior to testing of transfer effects, a control study was conducted in which twenty young adults (10 right-group, 10 left-group) were tested on a single day on both their legs using the same paradigm. We also evaluated whether there were inherent differences in motor skill learning between legs. The results indicated no differences between legs ($P> 0.05$) and demonstrated minimal inter-limb transfer in the single-day protocol. Evaluation of no-vision trials indicated that there was a clear transfer effect on the 2-Day protocol, whereas no transfer effect on the 1-Day protocol. These results indicate that repeated practice results in better inter-limb transfer when the learning of a task on the training leg has consolidated. The inter-limb transfer effects displayed in our target-tracking paradigm provide an opportunity to facilitate recovery of the impaired limb via training of the less impaired limb. The results have meaningful implications for gait rehabilitation in individuals with stroke or other neurological disorders.

Poster 36

Use of inertial sensors for determining rate of kicking in infants

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Purpose/Hypothesis: Our overall goal is to use data from inertial sensors to determine the quantity, type and quality of infants' leg movements performed across a full-day measurement for further use in the differentiation of infants with typical, delayed or impaired neuromotor development. Here we describe development of an algorithm to identify that a leg movement occurred.

Materials/ Methods: Inertial sensor data were collected from 12 infants with typical development for a period of 8-13 hours per day. There were 2 months between visits and a total of 3 visits per infant. An inertial sensor was attached to each leg, recording simultaneously accelerometer and gyroscope measurements at 20Hz. During each visit video data were recorded for 5 minutes. From the video data, trained behavior coders identified when a leg movement started and stopped. From the sensor data, we created an algorithm to define a leg movement. Accelerometer and gyroscope data were synchronized with the videos in order to compare the algorithm to the gold-standard video data.

Results: We developed an algorithm to define a leg movement. Each change of direction of the limb is counted as a discrete movement. Preliminary results for the total quantification of leg movements across a day (average of both legs) shows that at the first two months the infants presented less movement (28,000 movements/day), while at 3 months they demonstrated 43,700 movements and at 4 months they produced 81,500 leg movements per day. Across 5 to 9 months of age the movement quantity was consistent around 51,800 movements. Months 10, 11 and 12 fluctuate: at 10 months the total quantity was 63,000, at 11 months 42,000 and at 12 months it was 70,000 movements per day. In this preliminary analysis we have not yet adjusted for the infants' differing developmental skill levels, amount of nap time, or amount of time the sensors were worn.

Discussion: This work demonstrates that inertial sensors can identify infant leg movements from a full-day, in-home recording. We are currently determining the sensitivity and specificity of the algorithm. The use of inertial sensors is a very efficient way of having a portable in-home device for quantifying full-day infant movement to help the early detection of movement impairment. Future work will focus on the identification of the differences between typical, delayed or impaired neuromotor development infants.

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Poster 37

Capturing Upper Extremity Function with Acceleration Variability Metrics

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Background: Accelerometers non-invasively monitor upper extremity (UE) movement production outside of clinical settings. Advanced analytical techniques (e.g., machine learning) have been used to detect signals resulting from task-specific behavior and, thus, more precisely capture UE function in this context. Progress has been mired, however, by movement variability within and between individuals. Despite the problems movement variability poses for these techniques, quantifying metrics that characterize acceleration variability may be an effective, yet practical approach for capturing UE function outside of clinical settings.

Aims: 1) Examine the stability of metric associations with UE function when the paretic UE is engaged in task-specific behaviors; 2) Determine if the metrics are responsive to change in UE function; 3) Evaluate metric associations with UE function in the free-living environment.

Methods: Two samples of individuals with post-stroke UE hemiparesis, undergoing task-specific training (TST), were tested on the Action Research Arm Test (ARAT) and monitored with wrist-worn accelerometers. An outpatient sample (> 6 months post stroke, n=27) was tested and monitored during seven sessions of TST to address Aim 1. An inpatient sample (< 30 days of stroke, n=8) was tested and monitored pre- and post-intervention for 22 hours to address Aim 2. Recordings from 22 hours after one treatment session were examined in the outpatient sample to address Aim 3. Three metrics were calculated from data recorded during each monitoring period: 1) paretic UE acceleration variability ($AV_{Paretic}$), 2) acceleration variability of both UEs combined ($AV_{Bilateral}$), and 3) ratio of acceleration variability between UEs (AV_{ratio}).

Results: $AV_{Paretic}$ and AV_{Ratio} had a moderate-to-strong association with ARAT score over all seven sessions of TST, and $AV_{Bilateral}$ had a moderate association in all but one session. $AV_{Paretic}$ and $AV_{Bilateral}$ were sensitive to within-subject fluctuations in ARAT score across training sessions. AV_{Ratio} and $AV_{Paretic}$, along with ARAT score, increased significantly from pre- to post-intervention in the inpatient sample. AV_{Ratio} and $AV_{Paretic}$ were strongly associated with ARAT score in the free-living environment.

Conclusions: Acceleration variability metrics quantified via accelerometry capture UE function inside and outside of clinical settings. The metrics provide an objective method for clinicians to evaluate UE function, formulate treatment objectives, and individually tailor rehabilitation.

Poster 38

Amputation-related changes in inter-hemispheric interactions are reversible through transplantation of the human hand.

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Use of the intact hand by unilateral amputees is associated with increased activity in both the contralateral (intact) and ipsilateral (former) sensorimotor hand territories. Ipsilateral responses are believed to reflect reductions in normal levels of inter-hemispheric inhibition maintained by activity-dependent, transcallosal, GABAergic pathways. Former amputees who have undergone hand transplantation provide a unique opportunity to address whether these activity-dependent reorganizational changes can be reversed. If so, then following regeneration of peripheral nerves, movements of the intact (non-transplanted) hand should exhibit the same pattern as healthy adults, primarily activating contra- but not ipsilateral sensorimotor cortex. Here, we used functional MRI to map cortical sensorimotor representations in patient DR, a right-hand dominant male who suffered traumatic amputation of his left hand proximal to the wrist in 1998 (age 23) and underwent hand transplantation 13 years later (age 36). Patient DR completed the same protocol 15 and 26 months post-transplant. At 15 months post-transplant, DR showed a pattern of activation similar to amputees: specifically, he activated both contra- and ipsilateral sensorimotor cortices when moving his intact hand. However, when tested at 26 months post-transplant, patient DR showed a pattern of activation similar to controls: specifically, he activated only contralateral (but not ipsilateral) sensorimotor cortex when moving his intact hand. Between 15 and 26 months post-transplant, DR exhibited substantial improvements in hand functions that reflect regeneration of peripheral sensory and motor nerves. These results are consistent with the hypothesis that amputation-related changes in the normal inhibitory balance between sensorimotor cortices can be reversed when afferent and efferent activity between hand and brain is restored. The fact that this was observed in a fully mature brain has potentially important implications for understanding the role of experience in recovery from injuries to the central and/or peripheral nervous systems.

Poster 39

Restoration of cortical blood flow precedes spontaneous forelimb recovery after cortical infarcts in mice

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There is typically some degree of spontaneous recovery over time after stroke and neural plasticity in the peri-infarct tissue has been implicated

in this recovery. The temporal relationship between restoration of blood flow to peri-infarct tissue and spontaneous recovery has not yet been investigated. We studied this in a mouse model of post-stroke upper extremity impairments by repeated within-animal measures of blood flow changes in peri-infarct cortex, as assayed with multi-exposure speckle imaging (MESI), and forelimb functional changes, as assayed with the pasta matrix reaching task (PMRT). Fourteen C57/BL6 mice were first shaped to determine their preferred-for-reaching forelimb on the PMRT. Cranial windows were then installed over the forelimb area of the contralateral motor cortex. After 3 weeks of recovery from cranial window surgery, the mice then received 3 baseline imaging sessions, followed by 14 days of training on the PMRT to establish pre-injury skill. Mice then received photothrombotic cortical lesions of the forelimb representation of the trained motor cortex or sham procedures (n's = 7). Mice received forelimb probes using the PMRT in tandem with the imaging of cortical blood flow at Days 3, 5, 10, and 20 post-infarct. Infarcts significantly decreased performance on the PMRT and reduced cortical blood flow compared to both baseline levels and the sham group. Additionally, the re-establishment of cortical blood flow proximal to the infarct core preceded the recovery of motor performance. The temporal patterns of results are consistent with the possibility that blood flow recovery enables the adaptive plasticity required for motor recovery.

Poster 40

Forearm muscle activation in children with cerebral palsy and typically developing children during massed practice through adapted video game play

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Background and Aim: Developmental disregard observed in children with hemiparetic cerebral palsy (CP) leads to further reduction in excitability of the injured brain. Massed practice is thought to engage neural plasticity to enhance the motor outcome of those with CP. However the optimal form and intensity of massed practice is still unclear partially due to a lack of a home-based platform to deliver and monitor the practice. Unlike a commercial game console, a home-based system capitalizing on entertaining video games was developed that can only be played using individually specified joint motions for wrist and forearm rehabilitation. This study aimed to investigate the specific muscle activation patterns, fatigability and movement characteristics of children with and without CP while using the adapted video-game system.

Participants: Ten children with hemiparetic CP (four girls, aged 9 y 3 mo) and five typically developing children (TDC) (four girls, aged 8 y 7 mo) were recruited. All of the children with CP were at Manual Ability Classification System level II and had spastic forearm pronators and wrist flexors at the time of recruitment.

Methods: A video-game system containing an adapted controller was used in the study. The adapted controller can only be activated by specific wrist and forearm movements of each individual determined by therapists. Electromyography (EMG) was used to monitor muscle activations of wrist flexor, wrist extensor, supinator and pronator. Movements were recorded by a motion sensor in the controller. EMG and joint movements collected during six 3-minute games were stored on a computer for offline analysis. Movement rate (repetitions per second) and median frequency were derived. Median frequency alteration of muscle activations over time was used to indicate muscle-fatigability during 18-minute game play.

Results: Grouped data reveal TDC made 1.86 (0.86) repetitions per second, significantly more than children with CP did (1.44 (0.98)). During the game play, children with CP showed higher frequency components in wrist flexor and pronator EMGs than their counterparts ($p<0.05$). TDC demonstrated muscle fatigue while children with CP had less significant changes.

Conclusions: Children with CP were able to practice moving the target joints through the system proven by EMG and motion data. Although children with CP made fewer repetitions than TDC, in 30-minute game play, they could reach 2,466 repetitions, which is a greater number of repetitions than traditional rehabilitation programs. Although higher frequency EMG (fast-twitch fibers) was observed in children with CP, the muscle fatigue seen in TDC due to game play was not observed in them. This adapted video-game system may supplement the conventional rehabilitation in clinics. In this context, the incorporation of this system has the ability to enhance the motor outcome of those with CP by increasing the usage of an impaired arm.

Poster 41

Effect of burst stimulation by high frequency biphasic square-wave pulse on cortical perfusion after stroke: A pilot study

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Background: Functional electrical stimulation (FES) promotes motor function recovery after stroke, and is currently being used to establish normal gait pattern in patients recovering from stroke. However, the neural effects of this treatment in the central nervous system are not fully understood. In this study, we determined the effect of FES in patients recovering from stroke by monitoring cortical perfusion by positron emission tomography (PET).

Methods: Three patients with hemiplegia following chronic cerebral infarction (female: 2, mean age: 57.6 ± 9.5 years) were enrolled in the study (over 7 years after suffering a stroke). Three-dimensional H_2O^{15} PET studies were performed under four conditions: rest, voluntary contraction only on the paralyzed side, FES only, and simultaneous voluntary contraction and FES on the paralyzed side. After training of the lower limbs for 10 min with FES, brain perfusion imaging was performed two times during voluntary contraction only. First time immediately after training, the second time was 10 minutes after training. FES was performed with a two-channel portable electrical stimulator. The quadriceps on the paralyzed side were stimulated using stimulation-bursts of high frequency biphasic square-wave pulse at 2000 Hz carrier frequency, 100 Hz burst frequency, and 50% duty ratio. The stimulation intensity was adjusted to limit knee extension so that the subject felt no discomfort. The voluntary contraction task was a repetitive leg press exercise at 0.125 Hz with 10% load of maximal isokinetic strength. All procedures were carried out in compliance with the Helsinki declaration and were approved by the local ethics committee.

Results: Under voluntary contraction alone, brain activation was observed in the contralateral primary motor cortex (MI), bilateral supplementary motor area (SMA) and contralateral primary sensory cortex (SI). Under FES only, brain activation was not observed clearly. During FES-induced movement combined with voluntary contraction, brain activation was found in the contralateral MI, bilateral SMA, and SI.

The extent of activation in the contralateral SI was largest during voluntary contraction with FES. In the brain perfusion image after 10min from training, activation of the MI was attenuated after resting as compared to that observed immediately after training.

Conclusion: A pattern of training and burst stimulation by high frequency biphasic square-wave pulse of FES enhanced the activation of sensory areas of the brain. Further, this stimulation pattern led to attenuation of activation after training. In order to determine whether this phenomenon is due to the biphasic square-wave pulse, tests with monophasic square-wave pulse are required.

Poster 42

Paradoxical motor recovery from a first stroke by re-opening a sensitive period with a second stroke

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Background and Purpose: After stroke, there is a time-limited period of increased responsiveness to training due to heightened plasticity, which is thought to be induced by ischemia itself. Using a mouse model we have previously shown that most training-associated recovery after a caudal forelimb area (CFA – rodent primary motor cortex) stroke occurs in the first week and is attributable to reorganization in the medial premotor area (also called agranular medial cortex - AGm). The idea of a stroke-induced sensitive period leads to the counterintuitive prediction that a second stroke should reopen this window and lead to paradoxically enhanced recovery from the first stroke. To test this prediction, we induced a second focal stroke in the medial premotor area of mice with incomplete recovery after a first focal stroke in CFA.

Methods: C57Bl/6 mice were trained to perform a skilled prehension (reach-to-grasp) task to an asymptotic level of performance after which they underwent photocoagulation-induced stroke in CFA. After a 7 day post-stroke delay, the mice were then retrained for 21 days. A second photocoagulation-induced stroke was then induced in the medial premotor area and the mice were re-trained for 8 days after only a one-day delay.

Results: Focal CFA stroke led to a decrement in skilled prehension. Training-associated recovery of prehension begun 7 days after stroke induction was incomplete even with 21 days of training. At post-stroke day 21, a second focal stroke in the medial premotor area was induced, which now led to a dramatic response to training with recovery to normal performance after 8 days of training.

Conclusions: Together, these data indicate that new ischemia can re-open a sensitive period and mediate full recovery from a previous stroke. Future work will need to characterize what the critical molecular pathways are that ischemia triggers.

Poster 43

Clinical Implementation of an iPod-based Gait Assessment System for In-patient Stroke and Brain Injury Rehabilitation

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In-patient programs for stroke and brain injury rehabilitation in a tertiary hospital can consume significant clinical resources. Here we conducted a pilot study on an iPod based gait assessment and training system in the largest rehab center in metropolitan Beijing, China. Ambulosono System (AID Inc., Calgary, Canada) is a mobile technological platform that employs a suite of iPhone Apps to enable motion sensing, automated auditory feedback instructions, and cloud-based data logging and computing. To test its clinical applicability, we recruited consecutively 40 young and adult patients with acute stroke (F=24; M=4; age=37-62yrs) or other brain injury patients (F=7; M=5; age=13-71yr). These patients, who are considered a typical clinical cohort seen at our center, were followed up over a 5 month period. Initial baseline clinical assessment included: Fugl-Meyer Motor Assessment for Lower Extremity, Berg Balance Scale, Functional Ambulation Category, isokinetic knee muscle testing (Biodex System 4 Pro). Ambulosono-based interventions consisted of self-paced over-ground walking and task specific training (e.g. step length triggered auditory and music-feedback, obstacle negotiation, backward walking, and stepping in place, under both mono and dual task conditions). Testing and training data captured by the iPod Touch was transmitted to a cloud server for longitudinal analysis. Our results indicate: 1) gait parameters acquired through Ambulosono system are largely comparable to those reported in the literature. The average walking speed of stroke patients was around 0.51m/s. During training with step length triggered music-feedback, the walking speed increased to 0.89m/s. The average step length and time for music training were 0.55m (CV=0.28) and 0.65s (CV=0.23), respectively. Step length asymmetry between the intact and impaired limb ranged from 5 to 12%. 2) Task specific gait training using Ambulsono system also resulted in significant improvement in patients' walking speed and distance. 3) Post-Ambulosono training also led to significant improvements in baseline clinical assessment scores such as Berg Balance Scale (pre-Ambulosono training=47.8; post-Ambulosono training=51.1; $p = 0.001$).

Conclusion: The baseline gait data and post-training improvements in the current patient cohort are largely consistent with the studies that adopt verbal feedback in stroke gait rehabilitation. Mobile technology could therefore be utilized as a cost-effective tool to enable automatic gait assessment and training and readily implemented as in-patient rehabilitation program, particularly in large academic centers with intensive research activities.

Poster 44

Distinctive Impairment Profiles between Parkinsonian and Hemiplegic Gait Based on 6 Minute Walking and Dual Task Working Memory Tests

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Background: Functional impairments in gait and locomotion are common in Parkinson's disease (PD) stroke, and other forms of brain injury. Although Parkinsonian and hemiplegic gait show distinct kinematic features, few studies have compared the deficits of these two conditions in terms of their influence on patients' ability during ambulation using 6 minute walking test (6-MWT) and dual task challenge. 6-MWT is widely used as an outcome assessment tool based on the functional relationship between walking speed and walking distance. Dual task test is a measure of how cognitive and working memory load can further exaggerate the underlying gait deficit. Both measures can help define the extent and degree of functional impairments and assist planning in rehabilitation treatment.

Methods: Our multi-site study was carried out simultaneously in two academic centers, both utilized Ambulosono system (AID Inc. Calgary, Canada) to acquire walking data and conduct dual working memory test. The database comprised 77 PD patients and 41 stroke and brain injury patients with hemiplegic gait. Distance-speed plots were obtained from all subjects based on their average walking speed and the walking distance at best efforts, over a 6 minute period. For working memory and dual task test, we used selected items contained in MOCA (i.e. immediate-word-recall, serial-subtract-7, and delayed-word-recall) and asked subjects to perform these tasks while stepping in place.

Results: We found PD and hemiplegic patients show largely non-overlapping distribution on the speed and walking distance plot. In over 95% cases of the latter, the speed and distance is below 0.52m/s and 350m, respectively. In contrast, Parkinson's patients rarely walked at a speed below 0.5m/s. Majority of the patients can walk over 400m within 6 minutes. Despite more severe gait impairment, hemiplegic patients didn't show significant reduction in stepping cadence than mono-task condition as PD patients while simultaneously performing a second task ($P>0.05$). Such dual task conditions, however, induced marked reduction of stepping cadence in PD ($p<0.05$). Prolonged reaction time of serial-subtract-7 were revealed in both PD and hemiplegic patients ($p<0.05$).

Conclusion: Our data indicates that the influence of gait impairments on functional activity in hemiplegic and PD patients, albeit disabling, should be evaluated using different instruments in order to reveal the full extent and nature of the underlying motor control deficits. Our assessment protocol will be helpful in further development of more sensitive dual task tests for assessing working memory deficits in stroke patients.

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Poster 45

Improved sensation in a replanted or transplanted hand

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Former amputees that have had their injured hands replanted (heterotopic hand replants), or received transplantations of a donor hand (allogeneic hand transplants) provide a unique opportunity to evaluate the effects of deafferentation on the central nervous system can be reversed. Following sensory nerve transection and repair, peripheral nerve regeneration is estimated to proceed at a rate of up to 2mm per day. However, patients that undergo with surgical nerve repairs of the arm or hand show persistent difficulties in localization of touch without vision. This may reflect chronic disorganization of finger maps within the primary sensory (S1) cortex, as suggested by studies in nonhuman primates. We tested the hypothesis that central adaptations associated with extended experience can mitigate these functional limitations in right-handed heterotopic replant (N = 4) and allogeneic hand transplant recipients (N = 3).

We adapted the locognosia technique (Nordenboos, 1972) to measure the ability to localize light touch (100mN) on ventral surface of the hand and digits. This method allowed participants to see the position of their hand (eliminating proprioceptive demands), but not the location of the stimulus. On average, healthy adults localized touch with a very high level of precision, and exhibited no differences between sides (Right: Mean ± SD=4.00 ± 3.76, Left: 3.70 ± 3.40). Patients showed substantial variability (Affected Hand: 26.03 ± 24.75, Unaffected Hand: 4.77 ± 5.16), and a positive correlation between localization accuracy and time since hand replantation or transplantation. Two complete hand transplant recipients (8 and 10 years post-surgery) one mid-palm replant recipient (3 years post-surgery), and one full hand replant recipient (1.5 years post-surgery) exhibited the ability to localize stimuli on average within 95% confidence intervals of the control group on their affected hands. Time since the transplant/replant was correlated with performance ($r=-.63$).

Our findings suggest that hand transplant and replant recipients may recover a very high level of accuracy in touch localization. This ability may continue to improve for years following peripheral nerve repair and regeneration, and is perhaps attributable to central adaptations.

Poster 46

Spectroscopic evidence for lower neuronal metabolism and time-dependent increases in inhibition within the former sensorimotor hand territory of chronic unilateral amputees

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Background: Deafferentation and reduced efferent activity following limb loss precipitate functional reorganization in the sensory and motor cortical maps contralateral to the amputation. Animal models indicate several stages of central reorganization. Changes immediately post-amputation involve disinhibition of latent intracortical connections and are followed by synaptogenesis, axogenesis, and a reduction in the number of GABA neurons or its synthetic enzyme glutamic acid decarboxylase. Whether similar mechanisms underlie the post-amputation reorganization in humans is unknown. We addressed this issue through use of noninvasive proton magnetic resonance spectroscopy (1H-MRS). Relative to the hemisphere ipsilateral to the amputation, we predicted that amputees would show evidence of compromised neuronal metabolism (lower N-acetylaspartate, NAA) and reduced inhibition (higher glutamate-glutamine complex, Glx).

Methods: Eight (3 female) right-hand dominant, adult (46.5±9.9years), chronic (12.2±11.4 years), traumatic unilateral hand amputees (one missing the left hand) underwent functional MRI (fMRI), ^{1}H-MRS (water suppressed Point RESolved Spectroscopy) and structural MRI evaluations. Brain-tissue-corrected absolute concentrations of NAA and Glx were calculated in the cortical sensorimotor hand representations defined functionally: during fMRI, amputees executed finger flexion-extension with the intact hand while imagining comparable movements of the absent hand.

Results: Significantly lower concentrations of NAA ($p=0.005$) were found in the former sensorimotor hand territory compared to the intact hand territory. We found a non-significant ($p=0.3$) trend toward higher Glx concentrations in the former hand territory. A significant negative correlation was found between former hand territory Glx concentrations and time since amputation ($r=-0.73$).

Discussion: Our results provide initial evidence for lower NAA in the former sensorimotor hand territory following unilateral amputation in adults. The failure of the trend toward higher Glx to achieve significance may be attributable to the fact that use of the intact hand increases activity within the former hand territory. This may partially offset reductions in intracortical inhibition. The decrease in Glx with increasing time post-injury implies that the balance between excitation and inhibition changes in favor of increases inhibition with experience. Additional work is underway to decipher the functional implications of such change.

Poster 47

Facilitating supplementary motor area using near-infrared spectroscopy mediated neurofeedback improves postural stability but not hand dexterity.

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Background: There is accumulating evidence that the supplementary motor area (SMA) is involved in various aspects of motor control including postural control, inter-limb coordination, and coordinating temporal sequences of actions. However, its potential as a candidate for therapeutic target promoting functional recovery after stroke remains controversial.

Objective: To investigate whether the SMA facilitation affects the hand dexterity and/or postural control in cause-and-effect manner, we used near-infrared spectroscopy (NIRS) mediated neurofeedback (NF). The system aims to induce neuromodulation via voluntary control of cortical activities by real-time presentation (Mihara M et al. Stroke 2013;44:1091-8).

Method: Twenty healthy right handed subjects participated in this study (M: F = 7: 13, 28.1 ± 4.6 years old). As a marker for cortical activation, we used oxygenated hemoglobin derived signal measured by using a 50-ch continuous wave NIRS system with 4 short distance channels for correcting the extra-brain contamination.

NF session consisted of 16 repetitions of 5second - task and 8-16 second rest periods. Subjects were asked to control their SMA activation according to the feedback signals without specific strategic instruction. Each subject received the REAL session in which their own SMA activation was fed back and the SHAM session in which the SMA activation of other subjects was fed back, with an interval of more than one week.

Before and after each NF session, postural stability and hand dexterity were assessed using cumulative length of center of pressure (COP) displacement during standing and 9-hole PEG test score (9HPT) with non-dominant hand respectively.

NF effect on the SMA activation was assessed using comparison between first 6 blocks and last 10 blocks in each NF sessions. Behavioral changes were analyzed using repeated measures ANOVA with $p<0.05$ as significant.

Results: Group analysis of cortical activation revealed that the SMA activation was enhanced only in REAL condition. COP length was maintained in REAL condition whereas it slightly increased after NF in SHAM condition. On the other hand, 9HPT scores did not change after NF in both REAL and SHAM condition. There was significant interaction between group (REAL vs. SHAM) and time ($F_{1,38}=6.2$; $P<0.05$) on COP length, but there was no significant interaction on 9HPT, suggesting that the SMA facilitation improved postural stability but not hand dexterity.

Conclusion: Our findings suggest a cause-and-effect relationship between the SMA and postural control, and provided the rationale for SMA modulation as therapeutic target for balance disorder after stroke.

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Poster 48

Reliability of Ipsilateral Silent Period to Measure Interhemispheric Inhibition: Preliminary Results in Non-disabled Young Adults

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The ipsilateral silent period (ISP) is an index of transcallosal inhibition. ISP is a brief reduction in EMG activity following transcranial magnetic stimulation (TMS) applied to the primary motor cortex (M1) during voluntary ipsilateral muscle activation. Measures of ISP, such as duration or amplitude, are thought to reflect the balance in interhemispheric inhibition (IHI)-the extent to which homologous M1 areas mutually inhibit the contralateral side. An imbalance in IHI may be an important mechanism underlying impaired motor function after stroke, making ISP a useful and often cited measure. In stroke, ISP also allows for greater participant inclusion than other measures of IHI because it is assessed via stimulation of the non-affected M1. Our long-term goal is to measure ISP during volitional activation of the paretic hand in individuals with stroke, yet consistent methods for determining ISP for first dorsal interosseous (FDI) have not been established. Current studies have utilized a maximal contraction of the affected and/or ipsilateral hand, limiting the number of trials that could be completed before fatigue. While other studies have utilized submaximal contractions, it is not yet known whether the amount of force would impact the consistency of the ISP measurement. Therefore, the purpose of the current study is to investigate ISP under different percentages of maximal volitional isometric contraction (MVIC) to determine the optimal percentage of force that produces the most consistent ISP values for FDI among non-disabled young adults.

Four subjects were recruited to press against a force transducer isometrically using their dominant side's index finger abduction. MVIC was measured initially and used to calculate three force levels: 30%, 50% and 100% of MVIC. The subjects were asked to hold the predetermined force while a TMS pulse was applied over the non-dominant hemisphere. ISP was observed across force levels in all 4 subjects with 30% demonstrating the most robust observation. The ISP durations were 28.7±2.7, 26.4±8.6 and 22.9±11.7ms; while the ISP onset latency was 38.3±1.7, 36.4±2.8 and 38.2±3.7ms under 30%, 50% and 100% of MVIC, respectively. In summary, this is a feasible method to identify ISP for FDI in healthy young adults. ISP duration was longer and less variable (coefficient of variation (CV) = 4.3% vs.7.7% and 9.7%) under 30% MVIC across the 4 subjects. As ISP is a measure of precise interhemispheric interactions, we hypothesize that IHI may be a critical process for adjusting refined muscle contraction rather than for producing maximum force. Future studies will utilize the ISP measurement under submaximal muscle contraction to assess IHI following stroke.

Poster 49

Transcranial direct stimulation: modulating functional connectivity across pain networks

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Background: Chronic neuropathic pain is subtended by a complex circuitry, including sensory-discriminative and affective-emotional networks spanning several cortical and subcortical structures. Noninvasive brain stimulation is fast becoming popular as an investigational modality to affect pain experience. Stimulation, particularly anodal transcranial direct current stimulation (tDCS) applied to the primary motor (M1) or the dorsolateral prefontal cortices (DLPFC) represent two popular methods. However, it is still unclear how anodal tDCS of M1 versus DLPFC affects complex circuitry of pain, evidence that could provide better understanding as to whether they may affect varying aspects of pain experience.

Objective: To investigate and compare the effects of anodal tDCS to M1 versus DLPFC upon functional connectivity (FC) across cortical-subcortical networks of pain.

Methods and Design: Healthy subjects received either sham, anodal tDCS to M1 or anodal tDCS to DLPFC on three separate occasions. A seed-based FC analysis of the thalamus was conducted, and it's connectivity across cortical-subcortical pain networks were studied using resting state functional magnetic resonance imaging (rs-fMRI), before and after tDCS. Sham stimulation helped control for placebo or time-varying effects on FC. Activation maps of the M1 and DLPFC stimulation sessions were subtracted with the sham session to determine tDCS-specific changes. Finally, the validity of

tDCS on pain versus non-pain networks was tested by measuring the effects of stimulation on the FC of thalamo-occipital networks.

Results: Anodal tDCS to left M1 significantly increased the ipsilateral thalamic-M1 connectivity and decreased the coupling between ipsilateral thalamus and insula, as compared to sham. In contrast, anodal stimulation to left DLPFC significantly increased the FC of the ipsilateral thalamus with both the DLPFC and insula, but decreased ipsilateral thalamic-M1 connectivity. Thalamic-occipital connectivity was not modulated with any form of tDCS, validating the effect of tDCS on pain networks only.

Conclusions and future outlook: Since anodal tDCS delivered to M1 and DLPFC modulate connectivity differently across cortical-subcortical networks of pain, our evidence supports claims about their varying effects on pain. This is beneficial and can affect clinical practice of pain especially, as now, depending on the specificity of etiology, impairment level, and the duration of chronic neuropathic pain, patients may witness different responses to these two targets of stimulation.

Poster 50

RhoA Expression in Lamprey Brain Neurons After Spinal Cord Injury

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Disability following spinal cord injury (SCI) is due to failure of axonal regeneration. Axon growth may be inhibited by several types of inhibitory molecules in the CNS, including the chondroitin sulfate proteoglycans (CSPG), myelin-associated glycoprotein (MAG), Nogo and oligodendrocyte-myelin glycoprotein (OMgp). In the lamprey CNS, there are 18 pairs of individually identified reticulospinal neurons with heterogeneous axon regenerative abilities. Of these, the "bad-regenerating" neurons often experience a very delayed form of apoptosis. We have reported that the putative CSPG receptors, PTPσ and LAR, are expressed selectively in the bad-regenerating neurons both in normal lampreys and after SCI, when those same neurons were also undergoing apoptosis, as indicated by labelling with fluorescently labelled inhibitors of caspase activation (FLICA). It is thought that the intracellular signaling pathways activated by those inhibitory molecules, including PTPσ and LAR, converge on RhoA, whose activation has been implicated in both apoptosis and axon growth inhibition. To study the role of RhoA in SCI-induced retrograde neuronal death, we cloned lamprey RhoA, which was highly homologous to mammalian RhoA, and investigated its distribution in lamprey CNS by wholemount *in situ* hybridization (ISH) before and after SCI. RhoA expression in neurons increased during normal development in lamprey CNS. RhoA was continuously expressed in bad-regenerating neurons and in microglia/macrophages on cord surface after SCI, but was decreased greatly in most other reticulospinal neurons after SCI. Moreover, RhoA mRNA expression was correlated with caspase activation in brain at 2 weeks after SCI. The inverse correlation of RhoA expression with the intrinsic regenerative ability and survival post-axotomy is consistent with a role for RhoA signaling in triggering apoptosis and restricting axon regeneration after SCI.

Poster 51

Genotyping of brain-derived neurotrophic factor predicts response to single-pulse transcranial magnetic stimulation at rest

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Polymorphisms in the gene coding for brain-derived neurotrophic factor (BDNF) affect the ability of noninvasive brain stimulation to induce transient changes in corticospinal excitability. Measurements of the motor response to transcranial magnetic stimulation (TMS)-motor evoked potentials (MEP)-have long been used as a means of assessing excitability and plasticity in humans. Evidence suggests that the extent of aftereffects of repetitive TMS, theta burst and paired associative stimulation differ significantly based on BDNF polymorphisms. Specifically, carriers of 66Met allele of the BDNF gene are less susceptible to stimulation-induced modulations compared to those carrying Val66Val allele. While in these studies, susceptibility was defined by marked changes in MEPs after intense repetitive/rapid TMS paradigms or after motor training, it is conceivable that inherent differences in cortical excitability, influenced by BDNF genotype, could also affect evoked responses to simpler and less intense TMS paradigms at rest.

In a retrospective study, we examined a relationship between BDNF genotypes and response to single-pulse, aperiodic TMS in 21 healthy individuals (13 females; age: 25.4±7.98 years). Two single-pulse paradigms were explored: in subgroup 1 (n= 11), MEPs were evoked at 110% of subjects' resting motor threshold (rMT; ~50μV in 5/10 consecutive trials), while in subgroup 2 (n=10), intensities were adjusted so as to evoke MEPs of 1mV amplitude. In both subgroups, 30-35 MEPs were obtained from the right first dorsal interosseous as the subjects rested their hands. Functional variant Val66Met (rs6265) in the BDNF gene was genotyped using methods described in several prior studies. Genotyping was done by a technician, blinded to the identity of DNA samples, using Taqman assays on an ABI7900HT apparatus.

Fifteen subjects were homozygous for the val allele (Val/Val), 6 were heterozygous (Val/Met), and none were homozygous for the met allele (Met/Met). Controlling for age, sex and rMT, ANCOVA revealed that mean MEP amplitudes differed between BDNF genotypes ($F_{1,16} = 14.9$, $p=0.0014$) such that MEPs were significantly greater in subjects with the Val/Val genotype (1.09±0.3mV) compared to Val/Met group (0.53±0.24mV). In subgroup 1, 7 subjects carrying Val/Val and 4 carrying Val/Met allele were identified. Controlling for rMT, a main effect of genotype was found ($F_{1,8} = 5.38$, $p=0.049$), whereby mean MEPs were greater in subjects carrying Val/Val compared to Val/Met. Although the covariate rMT was not significant, rMT tended to be greater in subjects with Val/Met (66.7 vs. 49.5%). In subgroup 2, we found a similar pattern of results. Together, these findings suggest that although subjects were stimulated at individually-derived and fixed intensities, motor excitability was greatly diminished in Val/Met group.

These preliminary findings suggest that single-pulse TMS can be employed as an index of factors that affect neuroplasticity-an important variable in recovery after a brain injury including stroke-similar to other more complicated TMS paradigms.

Poster 52

Capabilities of the neurorehabilitation are under evaluated. A world wide stigma

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Background; Neurorehabilitation is a combined & coordinated use of medical, social, educational & vocational measures to retrain maximal physical, psychological, social and vocational potential. Obviously in the last decades it was focused mainly on motor recovery due to three main reasons:1st;limited awareness about other indications. 2nd;familiarity with motor rehabilitation. 3rd;faith about better outcome of motor rehabilitation.

Aim; highlighting the value of neurorehabilitation in nonmotoric indications. Aiming at raising awareness & state the add-on value of neurorehabilitation in these indications.

Methods; Case no.1; 52 years old Female unable to lute piano after a recent CVA. Sensory education (different textures + mirror training), OT, peripheral & central stimulation with (TENS & tDCS) respectively.
Case no.2; 21 years old female with history of TBI affecting higher brain functions. Cognitive assessment & training, PT & life style adjustment was initiated.
Case no.3; 50 years old female with uncontrolled hypertension & refractory headache. Non pharmacological management for muscle spasm & pain(muscle stretching, TENS, Ultrasonic stimulation & Infrared), deep friction massage as a relaxation technique, local nerve block together with patient education were initiated.

Results; Case no.1;could fiddle again her piano.
Case no.2;was assessed initially by ADDENBROOKE'S COGNITIVE scale, baseline score was 67 after a memory rehab exercises including physical, mental, stress control exercises & Mediterranean diet. Later on the patient was reassessed by the baseline scale & scored 72(5 degrees improvement). The mother confirmed this as the patient was back again to University.
Case no.3; was controlled regarding headache & blood pressure with less side effects & drug-drug interactions. A daily total reduction in the no. of bills received for both illnesses.

Conclusion; other avenues of neurorehabilitation can be as beneficial as that for motor recovery.

Poster 53

Longitudinal imaging of thalamocortical projections after stroke

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The large majority of stroke survivors must cope with chronic disability often affecting the upper limbs. Improved use of the stroke-affected limb is accompanied by neuroplasticity in intact tissues surrounding the stroke and modulating this plasticity should promote further gains in recovery. Sub-cortical brain areas are also affected by cortical stroke, and may contribute to recovery of function. One unknown issue in stroke research involves the role of the thalamus, the brain's relay center for sensory information en route to the cortex, in recovery from stroke in the forelimb area of the somatosensory cortex (FLS1). Thus, the aim of the current study was to elucidate the role of thalamocortical projections in recovery of function after stroke. We hypothesized that peri-infarct thalamocortical axons are damaged by stroke, but undergo structural plasticity during recovery. Adult C57BL/6 mice underwent a surgical procedure to inject a green fluorescent protein tagged adeno-associated virus (AAV-GFP) into the ventroposteriolateral nucleus of the thalamus, which sends projections to FLS1. Immediately following virus injection, an imaging window was implanted over forelimb and hindlimb S1. Axon terminals and cerebral vasculature were imaged in vivo using two-photon microscopy before and at various times after stroke to assess acute and long-term changes in vascular and neuronal structure and function. Peri-infarct blood vessels dilate at acute post-stroke periods, but quickly return to baseline diameter in the post-acute period. Preliminary data indicate that, surprisingly, a subset of thalamocortical axons survived within the infarct core, but suffered retraction and branch and bouton loss. Axonal boutons in both the core and peri-infarct cortex underwent high rates of turnover in the first week after stroke, with later stabilization. Overall, peri-infarct thalamocortical axons seem relatively resilient to the effects of ischemia, maintaining most branches and boutons, which may provide a scaffold for functional recovery after stroke.

Poster 54

Transcutaneous spinal cord stimulation to modulate spinal reflex excitability motor output after SCI

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Spinal cord stimulation (SCS) has been shown to both modulate and generate locomotor like electromyographic activity as well as to alter spasticity in individuals with spinal cord injury (SCI). Recent evidence has shown that transcutaneous (t)SCS can generate reflex responses similar to those elicited by epidural SCS but with reduced cost and invasiveness. It remains unclear however if there are certain stimulation frequencies at which tonic tSCS is most effective at reducing spinal reflex excitability and/or spasticity and whether the addition of stepping related afferent feedback further augments motor output. Therefore the goal of this research was to examine the effects of tSCS frequency on posterior root motor reflexes (PRMRs) and electromyographic muscle activation patterns recorded from healthy non-injured individuals and individuals with incomplete spinal cord injury during stepping in a robotic gait orthosis. We hypothesized that as frequency increases from 10-50Hz, excitability will first rise and then fall as some previous evidence has suggested. To achieve this, tSCS was delivered through stimulating electrodes placed over the T11/T12 intervertebral space (source) and reference electrodes placed on the abdomen (sink) and was applied at sub-motor threshold levels in non-injured and incomplete SCI subjects for up to 30 minutes. The results from the four healthy non-injured subjects, indicate that resting-state excitability is significantly modulated by sub-motor threshold tSCS though the effects of individual frequencies varied. In the individuals with incomplete SCI, tSCS at higher frequencies (50 Hz) demonstrated the ability to depress reflex excitability both during tonic stimulation and up to 5 minutes after the tonic stimulation was removed. Furthermore, during robotic assisted stepping in individuals with SCI, tSCS brought significant reduction ankle clonus during the stance phase. These results and previous evidence support the idea that transcutaneous spinal cord stimulation, like its epidural predecessor at or above 50 Hz tends to decrease responsiveness to afferent inputs and that future studies should focus on training with tSCS.

Poster 55

Impaired Modulation of Corticospinal Drive before Movement Onset after Spinal Cord injury

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Corticospinal drive is modulated in a task-dependent manner before movement onset in uninjured controls, which is thought to contribute to features of the upcoming movement. The extent to which corticospinal drive is modulated before movement initiation in individuals with damage to the corticospinal tract due to spinal cord injury (SCI) remains unknown. We tested patients with chronic (≥1 year) incomplete cervical (from C4 to C7) SCI and uninjured age-matched control during a simple index finger reaction time (RT) task. Using single pulse transcranial magnetic stimulation we examined motor evoked potentials (MEPs) in the first dorsal interosseous (FDI) muscle ~120 ms before the onset of ballistic isometric index finger abductions instructed by a visual stimulus presented on a computer screen. We

found that index finger RT was shorter in controls (299.1 ± 25 ms) compared with patients (361.1 ± 59 ms). We also found a speed-dependent modulation on MEP size in the FDI muscle in control subjects. FDI MEPs were larger in size when the movement speed increased at similar stimulation periods. In contrast, we did not observe the same modulation in SCI patients. Specifically, in patients FDI MEPs size did not increase progressively with shortening in movement onset. Thus, our results demonstrated an impaired ability to modulate corticospinal output prior to movement initiation after SCI. We propose that understanding these deficits might contribute to facilitate aspects of upcoming movements exerted by a partially paralyzed hand.

Poster 56

Cardiovascular responses to cutaneous nociceptive input after cervical spinal cord injury: role of pain afferent types and their plasticity

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In normal, anesthetized rats, stimulation of segmental (T6 - L1) dorsal cutaneous nerves (DCNs) generates different cardiovascular responses depending on which pain afferent types are activated. Stimulation of A delta fibers alone (0.5 mA) generates increases in heart rate (HR) but relatively limited decreases in blood pressure (BP), with this effect on BP being greater at higher stimulation frequencies (10 Hz vs 1, 2 or 5 Hz). Stimulation of both A delta and C fibers together (5 mA) generates the same increase in HR but now a greater drop in BP, especially at higher stimulation frequencies (2, 5, & 10 Hz). The temporal relationships between BP and HR changes show an initial drop in BP followed by an increase in HR followed by a recovery in BP and then a recovery in HR.

Following C7 crush spinal cord injury (SCI), we have found three cardiovascular responses based on BP, a depressor (normal) response where DCN stimulation at A delta and C fiber strength (5 mA) almost always generates a drop in BP, a pressor (autonomic dysreflexia) response where DCN stimulation almost always generates an increase in BP, and a dysautonomia response where there are mixed depressor and pressor responses to DCN stimulation at different spinal levels. We have now investigated the BP vs. HR relationships within these groups and found that the depressor response after injury is different than the normal response in that the final recovery of increased HR is delayed. This finding is also true in the dysautonomia response. In the pressor response, there are simultaneous increases in both BP and HR and both BP and HR are delayed in their return to baseline. In this last group, the effect is much greater in response to rostral DCN stimulation than to caudal DCN stimulation.

To relate these cardiovascular responses to pain afferent anatomical plasticity in the spinal cord dorsal horn, we transganglionically labeled A and C fibers with CTB and IB4 respectively in the T7 and T13 DCNs. In all injury cardiovascular responses, we found increased A fiber sprouting from both DCNs relative to uninjured animals. C fibers were fewer than, or the same as, in uninjured animals in both the depressor and dysautonomia response groups but showed sprouting in the pressor response group, significantly more so at T7 than at T13. Taken together, the normal animal data and the spectrum of cardiovascular responses and anatomical plasticity after cervical SCI, it would seem that A delta afferent input and plasticity preferentially affect HR responses and C fiber input and plasticity preferentially affect BP responses. This may mean that A delta effects could be predominantly cardiac while C fiber effects could be predominantly on vascular tone.

Poster 57

Effect of daily acute intermittent hypoxia on hand function in persons with incomplete cervical spinal cord injury

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Loss of hand function is a debilitating consequence of cervical spinal cord injury (SCI) and often results in significant reduction in functional independence. Most cervical spinal injuries are incomplete and endogenous hand recovery via use of spared pathways is slow and often inadequate to restore normal function. Thus, there is critical need for emerging therapies that enhance recovery of hand function after SCI.

Acute intermittent hypoxia (AIH) induces neural plasticity in rodents by increasing expression of plasticity-promoting proteins and strengthening synapses onto motor neurons to yield profound recovery of breathing and walking function. In rats with cervical SCI, daily exposure to AIH (dAIH) elicits profound recovery of both breathing capacity and forelimb ladder walking (Lovett-Barr et al 2012). We recently showed that AIH also facilitates motor function in persons with chronic SCI. A single AIH exposure increased ankle torque generation, while dAIH increased walking speed and endurance. Similar facilitation has been suggested to occur in the upper limb of spinal-injured humans. However, no studies have addressed this possibility. The purpose of this study was to test the hypothesis that daily AIH (dAIH) enhances hand function in persons with chronic cervical SCI.

To test this hypothesis, we carried out a randomized, double-blinded, crossover study in which 6 male subjects with chronic, cervical SCI (44±11 years old; C5-C7) received 5 consecutive days of dAIH consisting of 15 episodes of 1.5 min hypoxia (FIO_2 = 0.09) alternated with 1 min normoxia (FIO_2 = 0.21). Hand function was assessed at baseline, after the first and fifth intervention day (D1 and 5), and at follow-up (F) within one week. Primary outcome measures included hand speed (Jebsen-Taylor Hand Function Test), dexterity (Box and Blocks Test), grip strength, and maximum hand opening aperture. Co-activation of antagonistic muscle pairs at the hand and wrist was also measured during maximum hand opening. All results were compared with baseline and daily exposure to normoxia (dSHAM).

Hand speed (D1 p=0.017m F p=0.010), dexterity (D5 p=0.001, F p=0.006), and pinch strength (D1 p=0.010, F p =0.040) all increased more following dAIH as compared to dSHAM. Increases in hand speed were significant from baseline at follow-up (p=0.034), while increases in dexterity and strength were not significant likely due to the small sample size. Subjects also showed a significant increase in maximum hand aperture after dAIH (D5, p=0.031). No adverse events or significant changes in blood pressure or heart rate were found.

Overall, these results showed dAIH was safe and effective in enhancing hand function in persons with incomplete cervical SCI. dAIH may be particularly effective when used as a plasticity-promoting adjuvant with current rehabilitation therapies such as mass practice.

Poster 58

Impairments and Demographics Associated with Lateropulsion after Stroke: A Logistic Regression Analysis

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Background. Patients with lateropulsion following stroke ('pusher syndrome') present with other significant stroke deficits in addition to pushing toward the contralesional side when upright. These deficits are not a necessary condition for the presence of lateropulsion; however, they hinder recovery from lateropulsion and delay ultimate functional recovery.

Objective: The purpose of this study was to determine if logistic regression modeling would distinguish the presence of lateropulsion post-stroke, based on common stroke impairments or demographic factors, in a manner specific to lesion side.

Design: Retrospective chart review at an in-patient rehabilitation facility. Logistic regression analysis.

Methods: Electronic medical records of patients with stroke admitted to in-patient rehabilitation were designated into lateropulsion (LP+) and non-lateropulsion (LP-) groups via the Burke Lateropulsion Scale (with '2' or above signifying lateropulsion). Only patients whose admission motor Functional Independence Measure (FIM) scores were less than 30 and whose lower extremity scores on the Fugl-Meyer Assessment were 18/34 or less were included. Separate logistic regression tests were performed for left and right brain lesions using the binary variable (LP+ and LP-). Factors in the analysis included: demographic data (age and gender); admission values of motor status of the contralesional side (Motricity Index); proprioception (contralesional limb placement error test); vision (confrontation tests); and, cognitive Functional Independence Measure (FIM) scores. Chi-square analysis compared LP+ and LP- groups for visuospatial neglect as measured by the Star Cancellation Test and the Line Cancellation tests.

Results: 62.7% of LP+ and 74.7% of LP- with left brain lesions showed an association with age, gender, cognitive FIM and upper extremity Motricity Index in the logistic regression model. For right brain lesions, 66.7% of LP+ and 71.1% of LP- showed association with age, gender, cognitive FIM, lower extremity Motricity Index and limb placement error. Both models were statistically significant ($P<.001$). Neglect was more prevalent in the LP+ groups ($P<.002$).

Conclusion: In patients with stroke and poor motor and functional performance, patients with lateropulsion had more significant deficits than those without lateropulsion, especially with right brain lesions. Left and right brain lesions showed different influence of these impairments in logistic regression models. Increased rehabilitation time is indicated due to the negative influence of lateropulsion and these impairments on regaining vertical postural alignment and ultimate functional recovery.

Poster 59

Robot-assisted hand exercise compared with conventional exercise therapy after ischemic stroke: A pilot study.

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Background: Hemiparesis is a major cause of disability in stroke survivors. Existing rehabilitation techniques are frequently ineffective in restoring functional use of the upper limb post stroke; specifically insufficient hand function remains a limiting factor. Robotic therapies have been developed as exercise tools for stroke survivors. However, most upper limb devices have been developed to treat the shoulder, elbow and wrist, and not specifically the hand. The Amadeo robot provides retraining and range of motion exercises for hand function.

Objective: The purpose of this study is to better understand the efficacy of the Amadeo as compared to conventional rehabilitative therapies of the upper extremity in a population of chronic ischemic stroke survivors.

Patients & Methods: A total of 28 individuals at least six-months post stroke were recruited and randomized into two groups; 14 subjects received conventional therapy, and 14 received therapy with the Amadeo device. All subjects received one-hour therapy sessions, three times weekly for eight weeks. Conventional therapy consisted of range of motion exercises, joint mobilizations, strengthening and functional tasks. Amadeo therapy consisted of range of motion exercises at the hand as well as motor initiation activities and isometric exercises. The Upper Extremity Portion of the Fugl-Meyer (UEFM) was the primary outcome measure. Secondary measures included hand dynamometry (grip and pinch strength), the Nine-Hole Peg Test (NHPT), the Barthel Index, and the Motor Activity Log (MAL). Assessments were taken at baseline, on completion of therapy, and again at one-month follow up.

Results: Significant gains were seen on the UEFM in both groups. Within the conventional therapy group, the mean baseline UEFM was 44.7 and improved to 50.6 post treatment ($P=.005$). Gains were maintained at one-month follow up (51.3, $P=.005$). Improvements were also noted within the Amadeo group, with a mean baseline UEFM of 29.4, that improved to 31.5 ($P=.294$, (NS)) post-treatment and 34.4 at one-month follow up ($P<.05$). Increases in handgrip pinch strength on dynamometry were seen, but these gains failed to reach statistical significance. The MAL also showed gains in the conventional therapy group ($P<.05$), but not in the Amadeo group ($P=.400$). No meaningful improvements were noted in the NHPT nor in the Barthel Index.

Conclusions: Randomization resulted in an unexpected disparity of baseline functional ability between the two groups, making between group comparisons problematic. However, despite these differences, both groups achieved gains with training. It remains undetermined if this type of robotic therapy offers any benefit over traditional therapy.

Poster 60

Neurally dissociable information-processing components of reading deficits in subacute stroke

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A prevailing cognitive model of reading proposes that words are processed by interacting orthographic (spelling), phonological (sound) and semantic (meaning) information. To identify the brain regions critical for carrying out this information processing, we have so far performed neuropsychological testing and multi-sequence MRI on 5 patients with left-hemisphere stroke (<= 5 weeks post onset). We expected reading aloud to require all three components, while reading pronounceable letter strings (pseudowords, e.g., blork) can be completed without semantics. If a patient is able to read pseudowords, but not words, and especially words that do not follow typical spelling-sound patterns (e.g., yacht), this is described as surface dyslexia and is thought to arise primarily from semantic deficits. In contrast, if a patient has difficulty reading pseudowords aloud or making phonological judgments about them, this is described as phonological dyslexia and is thought to arise from deficits in mapping orthography to phonology. In our sample, two patients (P1,P3) were unimpaired across all three components, two patients (P2,P5) showed a pattern of phonological dyslexia, and one (P4) had a profound impairment in reading words and pseudowords. While lesion size predicted the overall degree of impairment, lesion location was crucial for predicting the type of impairment. In the two patients with phonological dyslexia, the damaged areas included the left corona radiata (CR)/internal capsule, with extension to thalamus and putamen in P5. P2, with a restricted CR stroke, achieved 83% accuracy in reading aloud words and only 33% accuracy for pseudowords, $t(178) = 8.51$, $p<.0001$. P5 also performed better on words (63%), than pseudowords (42%), $t(178) = 2.81$, $p<.01$. This is in contrast with similar performance on words and pseudowords in P1 and P4. P2 was relatively unimpaired on a semantic matching task (69%), but impaired on phonological (62%) and orthographic (67%) tasks compared to the two highest scoring patients. Relative to the other patients and a sample of 21 healthy controls, P2 showed exaggerated effects of word frequency, consistency, and their interaction. This is consistent with impaired orthography-phonology mapping and intact semantics. As we continue this study, we will evaluate whether spared deep fronto-parietal white matter connections to the thalamus are associated with intact orthographic-phonological mapping. Future studies will be useful investigating whether targeting reading therapies to impaired information processing components may be appropriate in the first weeks after stroke.

Poster 61

Proportional recovery of the upper limb after stroke depends on corticospinal tract integrity and not therapy

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For most patients after stroke, upper limb impairment resolves by approximately 70% of the maximum amount possible i.e., the proportional recovery rule (PRR; Prabhakaran et al., Neurorehabil Neural Repair 2008 22: 64-71). This presentation will demonstrate how the PRR relies on corticospinal system integrity as determined with transcranial magnetic stimulation and diffusion-weighted MRI. Data were obtained from 48 patients previously enrolled in an upper limb rehabilitation interventional trial. Upper limb impairment with the Fugl-Meyer assessment (FM) was measured 2, 6, 12 and 26 weeks after stroke. Patients received a standardised dose of upper limb therapy between weeks 2 and 6 (mean dose=553 min). Linear regression indicated that patients with an $FM_{initial}$ >10 recovered to a proportion (β) of 0.45, 0.60 and 0.69 of their maximum by week 6, 12 and 26 respectively, while patients with $FM_{initial}$<11 did not. Re-coding patients based on the presence or absence of paretic wrist extensor MEPs led to observed β of 0.48, 0.66 and 0.71 for MEP+ patients, with higher positive predictive power and specificity than categorisation based on $FM_{initial}$. For MEP- patients linear regression indicated that fractional anisotropy within the posterior limbs of the internal capsules (but not $FM_{initial}$) could differentiate between patients whose outcomes conforming to $\beta \approx 0$ versus $0 < \beta \leq 0.7$. Next, a separate group of 45 patients was examined within a rehabilitation setting. All were expected to make a proportional recovery based on the presence of MEPs within the first 5 days after stroke ($FM_{initial}$ range 3-65). For these patients, upper limb therapy dose was not standardised (mean dose=176 min). By week 12, the observed β was 0.68. Confirmatory findings were that for both samples, upper limb impairment resolved to ≈0.7 of the maximum possible. The novel findings were that proportional recovery occurred only for patients with functional corticospinal integrity. Patients without MEPs did not conform to the PRR but dichotomised based on structural corticospinal integrity. For patients expected to make proportional recovery, a plateau is reached between 6 and 12 weeks post-stroke. Proportional recovery is insensitive to therapy dose and may reflect the spontaneous neurobiological conditions that are unique to the initial days and weeks after stroke. However, there are at least two reasons why the present results should energise those who deliver upper limb therapy after stroke. First, the majority of patients must re-learn functional tasks in the presence of at least some lingering impairment; and second, tools which provide more direct measures of corticospinal integrity allow early identification of patients with "hidden" potential for upper limb recovery.

Poster 62

Interhemispheric imbalance of primary motor cortex excitability during spontaneous recovery after stroke

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The interhemispheric imbalance model predicts that balancing of corticomotor excitability after stroke is associated with greater improvements in motor function. However most of the evidence has come from studies of patients at the chronic stage. We carried out a retrospective analysis of longitudinal neurophysiological data collected from 46 patients during the first six months of recovery after first-ever ischaemic stroke. Transcranial magnetic stimulation was used to elicit motor evoked potentials and ipsilateral silent periods from both extensor carpi radialis muscles. We hypothesized that ipsilesional corticomotor excitability would increase during the spontaneous recovery process, and that this would be associated with greater improvements in paretic upper limb impairment and function. Corticomotor excitability became more symmetrical during the first twelve weeks of recovery. This was driven by an increase in ipsilesional stimulus-response curve slope and a decrease in ipsilesional rest motor threshold, which was associated with improved upper limb impairment and function. We found no evidence for a decrease in contralesional rest motor threshold or stimulus-response curve slope at any time within the first 6 months after stroke, and no evidence of asymmetric interhemispheric inhibition. Overall there was little support for 'balancing' of corticomotor excitability. Instead, neurophysiological recovery was confined to the ipsilesional primary motor cortex, with increasing excitability linked to motor recovery. Interventions applied during the sub-acute stage of stroke may be more beneficial if they facilitate ipsilesional corticomotor excitability directly, rather than attempting to do so indirectly through suppression of contralesional excitability.

Poster 63

Does Increasing Progenitor Cell Survival Improve Stroke Recovery?

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There is a significant increase in the number of progenitor cells (PCs) born in the neurogenic niches of the adult brain under ischemic conditions. These cells have been hypothesized to enhance neurogenesis, increase plasticity within the brain and promote stroke recovery. However, it remains to be determined if the PCs *per se* are causally important for recovery. Additionally, a majority of the PCs die by apoptosis and only a small proportion mature into neurons, suggesting that it would be necessary for cell-based therapies to prevent apoptosis in the PCs following a stroke in order to enhance stroke recovery. To evaluate this hypothesis, we quantified recovery from stroke in an inducible transgenic mouse that ablates the pro-apoptotic protein, Bax, from the PCs and their progeny. Focal cortical sensorimotor strokes were performed using the photothrombosis model in the nestin-CreER^{T2}/ floxed Bax (nBAX) and littermate control mice. Behavioral recovery was measured by the adhesive removal test (tactile response and asymmetries) and horizontal ladder task (forelimb and hindlimb placement, and coordination), which was assessed both prior to stroke and up to two months post stroke. Preliminary data analysis indicates photothrombosis stroke induced significant contralateral deficits in the nBAX and control mice in the adhesive and horizontal ladder tasks. In comparison to control mice, the nBAX mice had an increase in the number of PCs in the peri-infarct region at one month after removal of BAX from the PCs and their progeny, supporting that the nBAX mouse model increases PC survival. Ongoing work is increasing the sample size and adding in cognitive tests to determine if increasing PCs survival and neurogenesis is associated with improvements in learning or memory, which may aid in recovery post stroke. This work will determine if increasing PC survival is a viable option as a cell-based therapy for stroke recovery.

Poster 64

Spatial bias, the superior colliculus, and prism adaptation

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Objective: To demonstrate that externally modifying superior colliculus activity may lead to observable changes in spatial bias.

Background: Sprague 1966 first described an experiment where ablation of the contralesional superior colliculus (SC) led to improvements on spatial tasks in cats with induced parietal neglect. Since then, studies have shown that: (1) isolated deactivation of the SC may result in asymmetric spatial behavior, and (2) right visuoparietal damage may reduce input and activity in the ipsilesional SC. We hypothesized that stimulating the right SC may alter spatial performance bias. We also compared this effect with prism adaptation.

Methods: A.A. is a 29-year-old woman who presented with spatial bias and extinction following a right midbrain/collicular hemorrhage. On Visit 1, A.A. underwent a computerized line bisection task with and without SC stimulation with dual rotating checkerboards and right hemipatching. For comparison, on Visit 2, A.A. underwent the task before and after one prism adaptation training session (PAT; Goedert et al., 2013).

Results: A significant change in line bisection error was observed with both SC stimulation [baseline mean=2.1±6.53mm, stimulation mean=+2.2±5.36mm; $p<0.01$] and PAT [pre-prism mean=3.0±5.07mm, post-prism mean=0.7±5.42mm; $p<0.05$]. However, both SC stimulation and PAT shifted Aiming, motor-intentional errors rightward. This rightward shift tended to be higher in far space (SC $p<0.05$; PAT $p=0.07$).

Discussion: Superior colliculus activation and PAT may alter spatial bias via related mechanisms. In our participant, who had right SC damage, left SC activation may have resulted from visual stimulation. We observed reduction in leftward Aiming bias, which may have especially affected far space. Further research investigating SC stimulation and its long-term effects may results in novel or more effective treatments for disorders such as spatial neglect.

Poster 65

Stroke subtype and motor impairment influence contralesional excitability

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The non-lesioned motor cortex ($M1_{NL}$) is thought to be hyperexcitable in patients with subacute or chronic stroke and offers a promising therapeutic target. However, whether $M1_{NL}$ excitability behaves the same for subcortical and cortical strokes is unknown. We looked for correlations between the Fugl-Meyer (FM) score and $M1_{NL}$ resting motor threshold (RMT_{NL}) in 34 stroke survivors. FM correlated with RMT_{NL} for subcortical ($r=0.82$; $p=0.001$) but not for cortical strokes ($r=0.11$; $p=0.62$). We conclude that targeting $M1_{NL}$ with de-excitatory protocols is indicated more for subcortical than for cortical stroke, and that different therapeutic strategies may be warranted according to lesion location.

Poster 66

Putting transcranial magnetic stimulation, diffusion tensor imaging and functional MRI to the test: A study of interhemispheric imbalance in chronic stroke

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It is believed hand deficits persist in stroke due to an imbalance between ipsilesional and contralesional hemispheres. Imbalance has been characterized in a few different ways: output of the corticospinal tracts as well as their integrity using transcranial magnetic stimulation (TMS) and diffusion tensor imaging, mutual transcallosal inhibition studied using TMS, and cortical activation in movement of paretic hand noted with functional MRI (fMRI). However, it is unclear whether different substrates describing imbalance even offer complementary perspectives, and how they subtend clinical function. Across ten stroke patients (63±9 years) with chronic upper-limb paresis, we examined associations between substrates of hemispheric imbalance, and their relation to two widely used outcomes- one measuring impairment and the other perceived disability in voluntary use of paretic hand. We have found that patients with poorer integrity of corticospinal tracts in the ipsilesional hemisphere show greater output of these tracts in the contralesional. However, neither an imbalance in their integrity nor an imbalance of their output relates to transcallosal inhibition. As a converse, imbalance in cortical activation was associated with transcallosal inhibition. Patients with relatively high fMRI activation within ipsilesional than contralesional motor cortices not only possessed stronger ipsilesional corticospinal output, but also showed balance of mutual transcallosal inhibition. Clinically, while patients with poorer integrity of corticospinal tracts in the ipsilesional hemisphere showed greater impairments, those with reduced ipsilesional than contralesional cortical activation had greater perception of disability. In conclusion, although output of contralesional corticospinal tracts and ipsilesional damage relates, mutual callosal influence is only associated with relative cortical activation between hemispheres. Still, viability of corticospinal tracts appear useful in categorizing range of specific impairments, and helping realize potential offered by the contralesional hemisphere in recovery, while fMRI activation serves to mark disability in volitional use of the weak hand.

Poster 67

Positive dose response relationship for upper limb rehabilitation after stroke delivered unsupervised at home using the video game Circus Challenge

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Background Worldwide 12 million people survive stroke annually. Although recovery is significantly improved with intense and challenging physiotherapy, limited resources, particularly lack of therapists, prevent implementation of this evidence-base. Video games have the potential to overcome this barrier by delivering unsupervised therapy programmes.

Aim To determine if there is a positive dose-response relationship for upper limb therapy delivered to patients with hemiplegia after stroke, unsupervised in their home using the video game Circus Challenge.

Subjects and Methods Ethical approval and informed written consent were obtained. 53 patients (37 males), mean age 63 years, range 33-84 years were recruited, 23 within 4 weeks of stroke (Acute), mean time from stroke 2.3 weeks, range 0.9-4 weeks; 30 in the Chronic phase, mean time from stroke 1.8 years, range 0.5-9.7 years.

Circus Challenge comprises 10 mini games professionally produced specifically for upper limb rehabilitation controlled by 100 different bimanual movements, which together form the basis for activities of daily living. The time performing therapeutic control moves (not simply playing the game) is automatically recorded. Patients played the games unsupervised in their home over 12 weeks. The Fugl Meyer Upper Extremity Assessment (FMUEA) and the Chedoke McMaster Arm and Hand Activity Inventory (CAHAI) were undertaken at baseline and at 12 weeks and the changes in scores calculated. A MANOVA was performed for Acute and Chronic patient groups - Dependent variables: Change in FMUEA and CAHAI scores; Fixed factors: Sex, Hemisphere of stroke; Covariates: Dose - total time performing therapy moves, Baseline scores, Age, Time from stroke.

Results Baseline Scores - FMUEA, Acute: mean±SE, 41±3.0, range 12-59; Chronic: 39.9±2.3, range 13-60. CAHAI, Acute: 32.4±2.3, range 11-51; Chronic: 31.5 ±2.2, range 11-58. Dose - total time performing therapeutic moves, Acute: 182±35 minutes; Chronic: 337±57 minutes. Change in Scores - FMUEA, Acute: +13.7±2.5 ($p<<0.001$); Chronic: +5.3±0.8 ($p<0.001$). CAHAI, Acute: +16.6±2.4 ($p<<0.001$); Chronic: +4.3±0.8 ($p<0.001$). MANOVA revealed a main effect for Dose; Change in FMUEA, Acute $p<0.001$, Chronic $p<0.05$; Change in CAHAI, Acute $p<0.001$. For acute patients there were also main effects for Age, $p<0.04$ and Time from Stroke $p<0.02$.

Conclusion Patients aged up to 84 years play therapeutic video games unsupervised in their own home. The time spent performing therapeutic control actions during video-game play significantly predicted improvement in upper limb functional assessments. A positive dose-response relationship was observed in both the acute and the chronic patients indicating benefit can be gained from playing therapeutic video games even several years after stroke.

Disclosure Professor Eyre and Dr. Graham are applying for the IP to commercialise a cloud base clinical management and decision support platform designed to deliver therapy via video games.

Poster 68

An Algorithm Assessing Upper Limb Function After Stroke From Action Video Gameplay For Remote Monitoring Of Home Based Rehabilitation: Validity And Sensitivity To Change

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Background: Action video-games have been shown to provide structured home-based upper limb rehabilitation but there is also a requirement for clinically valid remote monitoring.
Aim: To derive an algorithm to assess automatically upper limb function during video gameplay which is clinically valid and sensitive to change.
Methods: Ethical approval and written informed consent were obtained. 37 patients (33-81 years) with hemiplegia after stroke, (20 chronic, 36-414 weeks post-stroke; 17 acute, 1-6 weeks post-stroke) played the rehabilitation game Circus Challenge daily, using commercial controllers (Sixense Ltd) that provide continuous 3D data of upper limb position and orientation. 8 blinded, clinical assessments using the Chedoke Arm and Hand Activity Inventory (CAHAI) were made per subject over a 12 week period. Kinematic variables obtained during gameplay on the same day, were used to derive linear models for CAHAI prediction for chronic and acute patients respectively, using the fitted R^2 as the selection criterion.
Results: The models derived for the acute and for the chronic stroke patients use 14 covariates (two in common) and a baseline CAHAI, and account for 96% (chronic) and 80% (acute) of the variability in clinically assessed CAHAIs. Cross-sectional validity was demonstrated using the between-subjects correlation coefficient ($r = .998$, $p< 0.001$; chronic $r=0.99$; acute $r=0.99$); longitudinal validity by the within-subjects correlation coefficient ($r=0.54$, $p<0.001$; chronic, $r=0.33$, $p<0.001$; acute, $r=0.63$, $p<0.001$). There was no difference between the model derived and clinically assessed CAHAIs in classification of patients to acute and chronic groups (comparing ROC curves, $p=0.50$), demonstrating similar sensitivity to change.
Conclusion: Automatic in-game assessment of upper limb function, generated solely using low cost, commodity hardware and action video-games, demonstrates the potential for clinically valid, remote monitoring of patients during action video-game delivered, home based rehabilitation programs.
Disclosure: Professor Eyre and Dr Graham are applying for the IP to commercialise a cloud based clinical management and decision support platform designed to deliver therapy via video games.

Poster 69

The impact of metabolic syndrome on cortical microvasculature - form and function

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Metabolic syndrome (MetS) is a leading risk factor for ischemic stroke. Given that nearly 25% of the world population has MetS, the number of stroke patients needing treatment will rise considerably in the coming years. As it stands, the only post-stroke therapy available to patients is rehabilitation. Animal models are extensively used to optimize human rehabilitation by developing therapies aimed at enhancing neuroplastic mechanisms. Nonetheless, the majority of animals used in stroke rehabilitation studies are young and healthy - they lack the co-morbidities of stroke patients. To better approximate the clinical condition, our lab is using a model of MetS, the Cafeteria (CAF) diet. Before initiating rehabilitation studies with this model, we will confirm that this diet exerts effects on the cerebral vasculature at the structural and, even more importantly, at the functional level.

CAF rats were provided with free access to standard rodent pellets and water as well as a varied daily supply of highly processed human junk food items (i.e. chips, cookies, bacon, etc.) and a 12% sucrose solution. After 3 months of treatment, CAF animals exhibit 4/5 criteria for MetS. CAF animals are overweight (CAF=767±16g, SD=676±13g), have increased circulating triglycerides (CAF=183±21mg/dl, SD=95±9mg/dl), reduced HDL cholesterol (CAF=70±4mg/dl, SD=94±3mg/dl) and impaired glucose tolerance (insulin: CAF=7.1±1ng/ml, SD=3.3±0.5ng/ml; blood glucose two hours after i.p. GTT test: CAF=8.5±0.7mmol/L, SD=6.7±0.3mmol/L).

We have succeeded in generating a rat model of MetS that closely approximates the clinical condition. Histological study of the cerebral microvasculature is underway with a focus on neovascularization following stroke as well as on damage to the endothelial wall. Further analysis is being performed to determine whether or not structural damage to the vessels is accompanied by functional deficits, as assessed via in vivo two-photon fluorescence microscopy. Concurrently, cognitive testing is being performed to determine whether CAF animals exhibit signs of emerging vascular cognitive impairment.

Poster 70

Use of Liquid Consistency Modification (LCM) and Augmented Hydration (AH) Orders for dysphagic patients following stroke

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Objective: To assess the effects of LCM and AH orders for optimizing hydration and functional recovery following stroke.

Background and Significance: Dysphagia with difficulty maintaining oral hydration is common following stroke, and warrants further study.

Methods: Records for our acute inpatient stroke rehabilitation unit were reviewed. Inclusion criteria were: ischemic stroke within 30 days and ability to take food, liquids and meds by mouth. Patients with non-oral feeding systems were excluded, as were those with congestive heart failure requiring a diuretic, chronic renal insufficiency, and inappropriate anti-diuretic hormone secretion syndrome. LCM and AH orders plus demographic, and outcome parameters were prospectively recorded. Differences in hydration parameters and FIM scores across

LCM and AH groups were assessed using the Kruskal Wallace statistic, and Spearman Rank-Order Correlations as appropriate.

Results: A total of 719 patients met inclusion-exclusion criteria. The mean age, length of rehabilitation hospital stay, admission Functional Independence Measure (FIM), discharge FIM, change in FIM scores, admission serum potassium, Blood Urea Nitrogen (BUN), BUN/Creatinine ratio, albumin and total protein levels were all significantly related to LCM assignment. For all of 8 progressively more intensely managed AH patient groups the serum sodium, potassium bicarbonate, (BUN), BUN/Creatinine ratio, albumin and total protein as well as urine specific gravity were all significantly related to intensity of AH intervention.

Conclusion: LCM and AH interventions can be initiated in a step-wise manner based on the severity of dysphagia. Their use is associated with significant differences in hydration parameters, as well as functional outcomes.

Poster 71

Effects of movement duration on use of the affected limb in individuals post-stroke

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Patients with stroke often exhibit non-use of their more affected arm: Although capable of generating arm movements, they often chose not to. Here, we hypothesize that the slowness of movements with the more affected side is a significant factor underlying such non-use. Twelve individuals with chronic stroke (mild to moderate impairment; 46.1± 9.0 on Fugl-Meyer assessment) and six age-matched non-disabled participants performed the Bilateral Arm Reaching Test (BART; Han, Kim, et al. 2014) in the forced and free choice conditions with three different movement time constraints: no time constraint, medium (~1000 ms, depending on target location) and fast (~ 500 ms). Arm kinematics, movement time, and task success were recorded across conditions and amount of use in the free choice condition was computed and compared to normative data. Whereas the non-disabled group showed no differences in hand choice across conditions, the stroke group showed decreased affected hand use in the faster conditions. A logistic regression model showed that the difference in affected limb use in the fast condition is predicted by the difference in movement duration between the affected and the less affected limb in the no time constraint condition. Further, individuals with left hemiplegia showed a dramatic decrease in use in the fast condition (68% decrease in paretic limb use compared to no time constraint condition), whereas individuals with right hemiplegia showed a only a 24% decrease in paretic limb use. We discuss our results in lights of the known right/left hand differences in arm control and in the framework of delayed rewards discounting.

Poster 72

Voxel-based lesion symptom mapping of factors related to language deficits after stroke

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Characterizing language deficits after left hemisphere stroke and understanding how they relate to lesioned tissue is complicated by the fact that multiple cognitive and linguistic skills are involved in performing any language task. To begin to address this complex problem, we combined factor analysis of behavioral data with voxel-based lesion symptom mapping (VLSM) of structural MRI data from 35 people with aphasia. Factor analysis is a statistical technique that provides insight into the relationship between multiple variables by creating a small number of factors onto which all variables load to varying degrees. VLSM relates brain damage to behavior on a voxel-by-voxel basis, so that the contributions of each area to a language task can be assessed.

The factor analysis of 26 different language and cognition tests using Eigenvalue>1 as the cutoff yielded 4 factors: word retrieval, speech comprehension, phonology/repetition, and executive function. Though a wide range of tests were included in the battery, the scores loaded logically onto these 4 factors. For example, the Philadelphia Naming Test loaded heavily on word retrieval, but very little on the other 3 factors. The yes/no questions from the auditory comprehension section of the Western Aphasia Battery loaded heavily on speech comprehension, but very little on the other 3 factors. Complete results from all tests will be shown. In order to determine how these factors related to the lesions of the 35 people with aphasia included here, we combined the results of the factor analysis with a VLSM analysis. Results showed that voxels were more likely to be lesioned in areas expected to be involved in tasks that loaded on the 4 factors described. The executive function factor was associated with middle frontal gyrus and fronto-parietal white matter lesions, the phonology factor with lesions to the ventral premotor and motor cortex, the comprehension factor with superior temporal areas, and the word retrieval factor primarily with inferior frontal cortex.

Poster 73

THE FUNCTIONAL ROLE OF ADULT NEUROGENESIS IN PROMOTING STROKE RECOVERY

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Following a stroke patients have an innate capacity to regain function. The cause of this recovery is proposed to be due to many forms of plasticity including adult neurogenesis, the process of generating new neurons in the adult brain. Preclinical studies in rodents have shown a significant increase in the number of adult generated progenitor cells (PCs) post-stroke and ectopic migration of PCs to the site of damage. In order to determine the function of the PCs, a few studies have ablated the PCs prior to generation of large strokes and have reported that PCs support stroke recovery. However, the timing of this effect and whether PCs would aid in recovery from a focal cortical stroke remains unknown. Therefore, this study aims to determine if neurogenesis per se is required for stroke recovery by using an unpublished transgenic GFAP-TK rat model (Heather Cameron, NIH). This model allows for the inducible deletion of GFAP-expressing cells in the adult brain by treatment with the antiviral drug, valganciclovir. PCs were ablated prior to a focal cortical stroke produced through injections of endothelin-1 (ET-1), a vasoconstrictive peptide, into the forelimb motor cortex. Long-term behavioral recovery was measured through three motor tasks: the staircase, cylinder and beam walk, in the GFAP-TK rats and littermate control wild-type (WT) rats. Preliminary results show that both the controls (vgcv treated and non-treated WT rats, and non-treated GFAP-TK rats) and vgcv treated GFAP-TK rats had significant deficits on the contralateral side in the staircase, cylinder and beam walk tests up to 4 weeks post-stroke. These results suggest that PCs are not required for recovery of motor function following a focal cortical stroke and ongoing studies are increasing sample size to confirm these findings. Additionally, we are testing whether neurogenesis per se is required for learning and memory during stroke recovery. Overall, this work will clarify the functional role of PCs during stroke recovery and thus help define their therapeutic potential for stroke patients.

Poster 74

Influence of depression and cognitive deficits on use of feedback for upper limb recovery in chronic stroke

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Background: Provision of salient feedback about movement patterns is essential for improving upper limb movement and function in people with stroke. Aside from sensorimotor impairments, post-stroke may have depression and/or cognitive deficits that can influence motor learning. However, how the presence of depression and/or cognitive deficits may limit the ability to use feedback in individuals post-stroke has not been elucidated. We evaluated the influence of depression and cognitive deficits on the ability to use feedback for learning upper limb motor patterns in people with chronic stroke.

Methods: Twenty-four people with chronic stroke practiced pointing movements to 6 targets throughout the arm workspace, 72 times/session for 4wks (12trials/target; three sessions/week). Targets were presented in a random sequence. In each trial, feedback was provided about movement speed (Knowledge of Results) and trunk displacement (Knowledge of Performance). Depression (Beck's Depression Inventory; BDI-II) and cognitive functioning were assessed before practice (PRE). Arm motor impairment (clinical, kinematic) and activity levels (clinical) were assessed at PRE, immediately after (POST) and 3mos after (RET) practice. Subjects were divided according to Beck Depression Inventory scores as those with (n=8; score $\geq$14/63; DEP group) and without (n=16; score$\leq$13/63; ND group) depression. Changes between groups in kinematic and clinical outcomes were assessed with repeated measures ANOVAs. Neurocognitive function was correlated with kinematic and clinical outcomes.

Results: All participants improved shoulder horizontal adduction range of motion and upper limb activity after practice. The DEP group had less clinical motor recovery at POST, used more compensatory trunk displacement and performed poorer on a reach-to-grasp task at RET. Improvements in kinematic outcomes were related to fewer deficits in memory and problem solving in both groups, and to better visuoperception and attention only in the DEP group.

Conclusion: The ability to use feedback, especially KP, was more impaired in the DEP compared to the ND group. People with depression and cognitive impairments had a decreased ability to use feedback for learning upper limb movement patterns. Information about the presence of mood and cognitive disorders can help clinicians select appropriate personalized interventions to maximize arm motor recovery post-stroke.

Poster 75

Vitamin D Levels and Stroke Severity in the Acute Inpatient Rehabilitation Setting

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Introduction: Multiple studies have shown a relationship between Vitamin D deficiency and the risk for developing cardiovascular disease and stroke, as well as an inverse correlation between Vitamin D levels and stroke severity. Putative mechanisms include effects of Vitamin D on renin expression and vascular smooth muscle relaxation, as well as inflammation and atherosclerosis. A recent study confirmed the link between low Vitamin D levels and risk of developing Alzheimer disease. However, insufficient data exists to support Vitamin D supplementation in the elderly to prevent heart disease or stroke, and concerns exist for potential side effects of unnecessary supplementation. We here ask the question whether a correlation exists between low Vitamin D levels and stroke severity upon admission to the acute inpatient rehabilitation setting. Such a correlation would support replacing low Vitamin D levels in the elderly in order to modify stroke severity.

Methods: This study included 532 ischemic stroke patients admitted to our acute inpatient rehabilitation program between January 2012 and February 2014. Admission Vitamin D levels were divided into quintiles. Disability severity as measured by Functional Independence Measure (FIM) and motor impairment as measured by Fugl Meyer Motor Score (FMMS) upon admission was compared for the highest (30.4-70.1 ng/ml, n=108) and lowest (4.5-12.5 ng/ml, n=106) quintile. Independent Samples t-test was performed to compare admission FIM and FMMS upon admission between the 2 groups. In addition, Pearson Correlations for Vitamin D level against FIM, FMMS, Interval post Stroke (IPS), age, length of stay at acute inpatient rehabilitation, number of co-morbidities, complications overall and infection related complications was performed.

Results: We found that there was no difference in mean admission motor (27±12 vs. 27±13; p=0.5), cognitive (17±6 vs. 18±7; p=0.9) and total FIM scores (44±17 vs. 44±18; p=0.7) between the highest and lowest quintiles of Vitamin D levels, indicating no difference in disability severity. Mean average impairment as measured with total FMMS was not significantly different between groups (25.9±36.7 vs. 27.8±37.3; p=0.3). Admission Vitamin D levels were not correlated with interval post stroke (r=-0.003; p=0.97), length of stay in inpatient rehabilitation (r=0.003; p=0.95), number of comorbidities (r=0.01; p=0.97) or number of complications during the inpatient rehabilitation stay (r=0.08; p=0.96). A weak but significant correlation existed between admission Vitamin D levels and patient age (r=0.172; p<0.01).

Conclusion: Even severe Vitamin D deficiency does not seem to predict increased stroke severity upon admission to an inpatient rehabilitation unit. Further, low Vitamin D levels do not seem to be correlated with an increased rate of complications during the inpatient rehabilitation stay. Our results argue against aggressive Vitamin D replacement as a measure to decrease stroke severity, or as a way to decrease complications in the post-stroke rehabilitation phase.

Poster 76

Can inertial sensors characterize treatment-induced skill acquisition in chronic stroke?

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In individuals with stroke, kinematics of upper extremity (UE) movements can provide performance-based information useful to distinguish between the restitution of skilled movements from those performance gains associated with compensatory movement strategies. A challenge of assessing kinematics is the difficulty in quantifying movement quality without expensive laboratory equipment. Wearable inertial sensors that measure limb accelerations and rotations can be used to quantify treatment-induced gains in motor control by characterizing the degree to which movement of the paretic UE approaches a gold standard multi-joint pattern. In this preliminary work, we demonstrate the use of a webcam and two synchronized wireless inertial sensors that are each comprised of a tri-axial accelerometer, gyroscope, magnetometer, and altitude sensor. Our purpose is to determine if inertial sensors can be used to evaluate movement quality through the application of principal component analysis (PCA). Methods: This study was undertaken as part of a larger clinical trial in which individuals with stroke received a physical therapy intervention. Sensors were placed on the proximal and distal

aspect of the paretic arm during the performance of a goal-directed, manipulation task--turning a knob using a grasp with repeated forearm pronation/supination movements. We describe the time course of skill acquisition in movement strategies for eight individuals with stroke at three time points. Principal component analysis (PCA) was used to identify the main contributing motions to the execution of the task. Results: PCA results reflected both between- and within-subject differences in multi-joint control. With practice, improvement in skill is characterized by decreased rotation of the proximal arm, and an increase in uni-planar rotation of the distal arm. Discussion: PCA can be used as a means to evaluate changes in movement quality both within and across subjects. We demonstrate that PCA can extract the key planes of motion in a discrete task, and provide a quantitative measure of skilled multi-joint control. This is a novel application of inertial sensors to capture the characteristics of movement, and by utilizing multiple sensors on an extremity, we can provide further insight than is typically afforded by observation alone. This work also forms a platform for developing feedback systems for patients, and may have application in the home environment.

Poster 77

Effects of task-oriented Exoskeleton Robotic Hand Training on Motor Function Recovery in Chronic Stroke: a six month follow-up study

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Objective: Following a cardiovascular accident most of the stroke survivors suffer from neurological impairments, especially in the upper extremity. Robot assisted exercise therapy has been a promising rehabilitation approach for stroke survivors which suffer from neurological and functional deficits. However, the numbers of rehabilitation devices focusing on hand function recovery are very limited, and it is largely unknown how the residual motor functions are influenced by the long-term effect of those devices. The aim of this study was to evaluate the long-term effect of a modified exoskeleton robotic hand system, which incorporates the residual motor functions and facilitates individual finger coordination, in a six month follow-up.

Methods: A chronic stroke patient (53 years old, 6 month onset) with a moderate left-arm hemiparesis participated in a 20-session task-oriented robotic hand training over a period of six consecutive weeks. The modified exoskeleton robotic hand used in this study enables task-specific practice of three different kinds of hand gestures: 1) full-hand grasping, 2) three-finger pinching, and 3) pincer grip. Wolf Motor Function Test (WMFT), Action Research Arm Test (ARAT), Fugl-Meyer Assessment (FMA), Modified Ashworth Scale (MAS), was used as efficacy outcome measures and the Minimal Clinically Important Difference (MCID) was used to describe the meaningful changes.

Discussion and Results: The patient demonstrated a significant improvement after intervention in the outcome measures, which maintained in the six month follow-up. The clinical scores improved 29.5 points in the WMFT (> MCID 1.0), 42.5 points in the ARAT (>MCID 5.7), 34 points in the FMA (>MCID 6.6), and a time decrease in the WMF of -63.43 seconds (< MCID -19.0sec) for the six month follow-up. Substantial increases of the outcomes indicate an improvement of the voluntary motor functions of the upper extremity and hand in particular. These findings support our objective and coincide with other studies of robot-assisted rehabilitation. However, the main limitation of this study is the small sample size; therefore, further investigations are needed to determine the findings in a larger randomized clinical trial.

Conclusion: This case study examined the feasibility and effectiveness of a task-oriented exoskeleton robotic hand training on one chronic stroke patient with a moderate hemi paresis. Although the sample size is limited, the results of this study are encouraging that the robotic hand training could facilitate the motor recovery of the upper extremity.

Poster 78

Improved spasticity correlates with change in contralesional cortical thickness, following upper limb motor therapy

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Introduction: Spasticity has a significant impact on the daily function of chronic stroke survivors. The neuroanatomical basis of spasticity remains poorly understood. An accepted current measure of spasticity entails the velocity-dependent stretch reflex. This measure activates a complex array of sensory, motor and pain-related neural pathways, rendering very difficult the study of neuroplastic changes related to spasticity. The purpose of this study was to investigate the brain correlates of improved spasticity according to structural brain change, specifically cortical thickness.

Methods: Twenty-eight chronic (>6 months) stroke survivors were enrolled. Modified Ashworth Scale (mAS) and MRI T1 images were obtained before and after a 12-week intensive motor learning therapy. mAS was summated for nine upper limb muscle groups. Cortical thickness (CT) was computed using Freesurfer's longitudinal processing stream. Fractional change in cortical thickness was defined as follows: (post–pre)/pre thickness. Using Freesurfer general linear regression analysis, we identified clusters where fractional change in CT was correlated with change in mAS while controlling for subject's age, baseline mAS score and change in motor function according to Arm Motor Ability test (AMAT; function quality domain). Cluster-wise correction for multiple comparisons was performed with Monte-Carlo simulation at $p<0.05$.

Results: Cohort characteristics were: 56±13 age, 36% female, 2.0±1.4 years after stroke. mAS score improved from 7.3±2.8 to 4.8±2.6, $p<0.0001$. AMAT improved from 1.8±0.7 to 2.29±0.9 ($p<0.0001$), a total improvement of .49 points, which was double the reported minimally clinically significant change (.21). Improvement in spasticity was statistically significantly associated with decrease in cortical thickness in the contralesional superior frontal gyrus (cluster size = 649.2 mm^2; peak vertex coordinate in MNI space x=9.2, y=37.1, z=50.4; cluster-wise $p=0.001$), after controlling for motor improvement, age, and baseline mAS. No statistically significant clusters were identified in the ipsilesional hemisphere.

Conclusion: Change in cortical thickness can provide insight into neuroplastic brain change in response to treatment, and is potentially related to spasticity and its mitigation. Premotor and prefrontal cortices are multifunctional regions that are responsible for high order motor control, attention and sensory coordination. Our finding of cortical thinning in the contralesional superior frontal gyrus, paralleling improvement in spasticity, may indicate reorganization and functional change in this area, as result of rehabilitation and suggests a its potential role in spasticity.

Poster 79

CHANGES OF MOTOR RECOVERY IN CHRONIC STROKE PATIENTS

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OBJECTIVE: Determine changes in motor function recovery in stroke survivors who perform standard rehabilitation therapy during the chronic phase of their disease.

DESIGN: Descriptive and retrospective study based on consecutive records of chronic stroke patients.

SETTING: Rehabilitation Center in Bogotá, Colombia.

PARTICIPANTS: 61 patients with motor sequelae of stroke with clinical evolution longer than 6 months. [Average = 13.20 months]. All patients were being treated with a standard protocol for stroke rehabilitation with conventional physical and occupational therapies.

INTERVENTIONS: Not applicable.

MAIN OUTCOME MEASURES: Functional changes obtained between 2 consecutive clinical records [Average time between assessments = 8.3 months] in scores of the following scales: Fugl-Meyer Motor Scale (FM), Postural Assessment Scale For Stroke Patients (PASS), Five Times Sit To Stand Test (FTSST), Modified Rankin Scale (MRS), Barthel Index, Composite Functional Index, Modified Ashworth Scale.

LEVEL OF EVIDENCE: 3

RESULTS: We found significant changes to functional recovery between the scores of first and second assessment at all scales applied (P=<0.05); however the effect sizes were small. [FM upper limb d= 0.186, FM lower limb d=0.150, PASS d= 0.169, Barthel d= 0.413, Composite Functional Index d= 0.420].

CONCLUSIONS: In stroke patients who continue performing a standard protocol for stroke rehabilitation, after six months of evolution still continue showing small changes to motor function recovery. These changes are statistically significant.
This study strengthens the knowledge about the pattern of functional recovery and prognosis of motor recovery in chronic stroke patients, providing a basis for objective and accurate assessment of therapeutic responses in clinical practice and future research protocols.

Poster 80

Combination of transcranial magnetic stimulation, botulinum toxin A and intensive occupational therapy facilitate functional recovery of stroke patients

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【Purpose】We examined the effect of combined therapy with low frequency (1Hz) repetitive transcranial magnetic stimulation (rTMS), botulinum toxin A (BTX-A) and intensive occupational therapy (iOT) for functional recovery of paralyzed upper extremities (U/E) after stroke.
【Methods】The study sample includes 18 stroke patients in both recovery (n = 7) and chronic (n = 11) stages who were treated with the combined therapy for 14 days in inpatient hospital settings. The patients at a recovery stage were within 6 months of stroke onset and did not have any improvement of paralyzed U/E before the combined therapy at least for one month. The patients at chronic stage were those whose function of the paralyzed U/E did not change for at least 6 months after the completion of a conventional inpatient rehabilitation program. In order to assess the condition of the corticospinal tract integrity for each patient, we measured fractional anisotropy (FA) at cerebral peduncle using functional MRI, and then, FA asymmetry was calculated for all of 18 patients (Stinear CM et al., 2007). For rTMS treatment, 1,200 stimulations of 1Hz at 90% of rest motor threshold were applied over the motor area on non-lesional hemisphere of brain twice a day. Each patient received the iOT of 2 hours twice a day just after each rTMS application. BTX-A was administered to 10 patients with U/E spasticity on the first day of training. The following measures were evaluated before and after the combined therapy: Fugl-Meyer Assessment (FMA), Action Research Arm Test (ARAT) and Wolf Motor Function Test (WMFT). Wilcoxon's signed rank test was used to examine the differences.
【Results】FA asymmetry was not associated with the prognosis of U/E function. The scores and time of FMA, ARAT and WMFT (n = 18) before the therapy were 32.2 ± 2.5 (average ± SE), 18.4 ± 3.7 and 658 sec, respectively. These scores and time after two weeks of the therapy were 41.9 ± 2.7, 27.5 ± 4.6 and 488 sec, respectively, showing significantly improvement with the therapy (FMA, $p < 0.001$; ARAT, $p < 0.001$; WMF, $p < 0.01$).
【Conclusion】 Two weeks of the combined therapy for stroke patients exhibited functional improvements of paralyzed U/E.

Poster 81

Heart rate variability is associated with upper extremity recovery after stroke

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Among the 795,000 individuals who sustain a stroke annually in the United States, almost 65% are unable to use their affected upper extremity (UE) in daily tasks resulting in costly resource use to support long-term independence. UE rehabilitation is most efficient when restorative interventions, which seek to improve affected UE function, are focused on patients with good potential for UE recovery early in the rehabilitation process. Unfortunately current predictors such as location and volume of stroke and initial UE impairments are poor predictors of UE recovery after stroke. Identifying novel biomarkers of UE recovery will allow clinicians to more accurately predict patients with potential for UE recovery and provide targeted interventions to enhance long-term independence.

Heart rate variability (HRV) or the temporal variations between consecutive heartbeats is a plausible proxy marker for the integrity of cortical pathways controlling UE function. HRV directly measures the intact function of the vagus nerve, which controls the autonomic functions of the heart, and is modulated by the cortical pathways controlling UE function. We examined whether HRV upon admission to acute inpatient rehabilitation is associated with UE recovery three months after stroke. We hypothesized that individuals with higher HRV at acute inpatient rehabilitation admission would exhibit greater UE recovery after 3 months. This is the first step in developing a prediction model using HRV to predict UE recovery after stroke.

A 12-lead Holter monitor was attached for 24-hours to 10 patients with stroke [mean age = 61 years (SD =12), 7 females, 7 ischemic and 3 hemorrhagic stroke] within three days of admission to acute inpatient rehabilitation. Standard deviation between the consecutive heartbeats (SDNN) was used to quantify HRV. Fugl Meyer Upper Extremity Subscale (FMUE) was used to assess UE recovery at three months after stroke. In our sample, HRV upon admission was strongly (R^2= .80) and significantly (p =.009) associated with three month FMUE scores. Individuals who had higher HRV showed greater UE recovery three months after stroke.

Our findings suggest that HRV is a plausible biomarker to predict UE recovery after stroke. Using HRV is novel, inexpensive, and easy to administer. Future studies will examine whether HRV can predict UE recovery after controlling for covariates (age, stroke location and volume, time since stroke and amount and type of rehabilitation).

Poster 82

Interhemispheric frontal resting connectivity increases in post-stroke aphasia and is associated with worse performance

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The role of the right hemisphere in aphasia recovery has been debated for over a century. Some argue that the right hemisphere

plays a compensatory role, aiding recovery (e.g., Basso et al., 1989), while others posit that right hemisphere activity interferes with recovery (e.g., Barwood et al., 2011). Recently, research has shifted to examining connectivity, rather than activation levels, in order to better understand neural patterns that explain aphasia symptoms and recovery (Bonilha et al., 2014). This approach is critical because some differences in task-related activity in aphasia may relate to differences in the effort required for task performance rather than actual reorganization of language networks. This experiment examined the resting state networks associated with right BA 44 and performance on a range of language tasks. Twenty participants with left hemisphere lesions and aphasia diagnoses, as well as 21 age matched controls, participated in this study. The participants underwent a 7 minute T2* weighted resting state MRI scan, as well as a high-resolution structural scan. Participants also underwent a battery of language and other cognitive tests. The time course in right BA 44 was extracted for each participant. The model used the time course in right BA 44 as the predictor, and included motion parameters as covariates. At the group level, participants with aphasia showed greater connectivity to right BA 44 in the left and right middle temporal gyrus, right inferior temporal lobe and left insula, compared to controls. The peak difference in connectivity was in the left insula. Participants in the aphasia group were then grouped based on whether each individual's lesion overlapped with this peak (10 in each group). Participants with lesions overlapping with the peak showed significantly impaired performance on a range of language tasks, relative to patients whose lesions did not overlap with the left insula, and controlling for lesion size. Finally, connectivity between the left insula and right BA 44 was measured for each aphasic participant who had a preserved left insula. Connectivity in this group correlated negatively with performance tests of oral word reading tasks and speech apraxia, controlling for lesion size. These results demonstrate that connectivity between left and right frontal lobes increases after a left hemisphere stroke, and that this over-connectivity is related to worse performance on certain speech measures. Additional analyses will be needed to determine if similar connectivity relationships are observed with other areas of the right hemisphere.

Poster 83

Multimodal predictors of rehabilitation related recovery in stroke

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Stroke is the leading cause of upper limb disability. Unfortunately, variability in stroke location and impairment results in different rates of recovery. Therefore, in order to accommodate the wide patient variability, therapists often use functional tests to aide in development of individualized therapy. However, while baseline function is significant in predicting recovery, it is often limited since patients with the same level of impairment can improve via different neural processes. Knowing the unique process of recovery would allow one to individualize therapies for better outcomes. Therefore, here we investigated if initial assessments of corticospinal integrity (diffusion tensor imaging), corticospinal output (transcranial magnetic stimulation), interhemispheric inhibition (ipsilateral silent period), or cortical activation (functional magnetic resonance imaging) could be predictors of recovery following a five week therapy session. Recovery was defined in terms of impairment, dexterity, and perceived disability. Stepwise linear regressions were used to find predictors of recovery. In addition, we also determined if patients' neural substrates could be predictors of long-term (3 month) follow-up recovery. Notably, we found that predictors of alleviating impairments were both corticospinal integrity (β=0.537, R2=0.975, p=0.001) and corticospinal output (β = -0.604, R2=0.975, p=0.001). Corticospinal integrity and corticospinal output were also found to be predictors of perceived disability, but only after long-term follow-up (β=0.814, R2=0.999, p=0.001; β=0.613, R2=0.999, p=0.003). Finally, we identified interhemispheric inhibition as the only significant predictor of dexterity improvement (β=0.781, R2=0.61, p=0.013). It is important to note that cortical activation did not show significant contribution to recovery. . However, while baseline function is significant in predicting recovery, the only baseline test found to be a predictor of recovery was perceived disability (β=0.726, R2=0.527 p=0.027). Therefore, the results from our study suggest that corticospinal output and integrity may be a better measure to predict reduction of impairments in stroke patients. Likewise, recovery of dexterity may be best predicted by interhemispheric inhibition. Therefore, future work should consider including measures of corticospinal integrity, corticospinal output, and interhemispheric inhibition to further tailor therapy to individual patients' neural processes.

Disclosure: Andre Machado has the following conflicts of interest to disclose: Intelect medical (advisory board, consultant, shareholder), ATI, Enspire and Cardionomics (distribution rights from intellectual property), Functional Neurostimulation (consultant), Deep Brain Innovations (consultant).

Poster 84

Aphasia severity relates to right supramarginal gyrus grey matter volume after accounting for lesion-related factors in chronic stroke

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Aphasia is a common consequence of left hemispheric stroke. Evidence has shown that lesion size and location in the left hemisphere contribute to severity of post-stroke aphasia. Enhanced activation in perilesional left hemispheric areas as well as activation in certain areas of right hemisphere have been observed after damage to the left hemispheric language network. However, the potential contribution of residual left or right hemispheric areas to aphasic deficits remains elusive. In the present study, we assessed whether grey matter (GM) in preserved brain areas was associated with aphasia severity in chronic stroke.

Twenty-four patients (age: 58.6±10.2) with chronic post-stroke aphasia and 26 healthy controls (age: 61.0±10.4) participated in the study. All patients were administered a battery of language and cognitive tests and a high-resolution 3D T1-weighted structure image was collected from all patients and controls. Voxel-based Lesion-Symptom Mapping (VLSM) was performed to determine the lesion location that best predicted impairment on different language measures, and the lesion status at the peak voxel in each VLSM analysis was recorded for each patient in order to account for variance related to lesion location in subsequent analyses. For each language measure, voxel-based morphometry (VBM) was then used to examine the correlation between GM volume and the language score, while including age, time since stroke, total lesion volume, and lesion status from the VLSM analyses as nuisance covariates. Regions-of-interest (ROIs) were then applied to compare the difference in GM volume between patients and controls.

The VBM results showed that when controlling for age, total lesion volume, time after stroke, and lesion status, the GM volume within right supramarginal gyrus (SMG) positively correlated with aphasia quotient, spontaneous speech and repetition ($p<0.05$, AlphaSim correction). Volumes of right SMG negatively related to age in patients (p=0.03). No correlation was found between right SMG volumes and lesion size ($p>0.05$), and no difference was found between SMG volumes in patients and controls ($p>0.05$).

These findings suggest that right SMG volume contributes to aphasia severity in chronic stroke. The lack of relationship with lesion volume and the lack of difference in GM volume between patients and controls suggest that SMG volume may not change markedly after the stroke, but rather that right SMG volume prior to left hemisphere stroke determines resilience to aphasia. Longitudinal studies of GM anatomy after left hemisphere stroke will be needed to examine these relationships more thoroughly.

Poster 85

Recovery of Life Role Activities and Underlying Impairment Gains In Response to Comprehensive, Integrated, Milieu Intervention for TBI Survivors

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Purpose: The purpose of the study was to develop and test a comprehensive cognitive and motor intervention for moderately impaired TBI survivors.

Methods: Inclusion criteria were: ≥18yrs of age, ambulatory at least with a walker or cane and stand-by guarding, both upper and lower limb weakness/dyscoordination, attention deficit (tested with the Attention Process Training tests), independent with self-care of toileting and eating lunch, verbally understandable, and able to follow two-step commands (e.g., 'hold the bar, and shift your weight to right leg'). Five participants were enrolled (4 years, 2 years, 7 years, 20 years, 4 years after TBI, respectively) in an A-B, case-controlled design with 3 months of no treatment, followed by treatment 5 hours/day, 5 days/week for 12 weeks. Training schedule was as follows: 1¼ hrs, cognition; 1¼ hrs upper limb function; 1¼ hrs balance and strengthening; and 1¼ hrs gait training. The primary measure was achievement of gains in life role activities, assessed according to the unique goals and dysfunction for each subject. Outcome measures were obtained at pre- and post-treatment and 3 months follow-up: structured interview; mood (Beck Depression); emotion function (self-report and observation by team members and family members); battery of neuropsychology measures of attention, memory, and executive function (Stroop, Cancelation Task, Trail Making, California Verbal Memory, Wechsler Memory, Digit Span, Wisconsin Card Sort; upper and lower limb muscle strength (manual muscle test (MMT), muscle tone (Modified Ashworth Scale (mASH), and isolated joint coordination (Fugl-Meyer Coordination Scale (FM); balance (Berg Balance); gait coordination (Gait Assessment and Intervention Tool (G.A.I.T.) and kinematics; function (Functional Independence Scale (FIM overall and 2 subscales); and quality of life (life role participation; Craig Handicap Assessment Tool (CHART overall; and 6 subdomains) and grocery shopping (TOGS); and video documents of gait and life role activities before and after treatment. The intervention and environment was different from standard care as follows: 3 participants were treated in a group; all participants interacted with each of four therapists daily; thus they were immersed in a therapeutic milieu.

Results: Each of the five participants achieved one of their main life role participation goals during the study, which were as follows, respectively: completion of high school and GED; registration and initiation of college course; registration and acceptance into a vocational rehab course for automotive mechanics; fishing with buddies; and control of emotional and physical outbursts with normalization of interpersonal relationships. Gains were exhibited in underlying impairments of mood, attention, memory, executive function, muscle strength and tone, coordination, balance, gait coordination, and functional activities, and other life role participation activities.

Clinical significance: Even though participants were years out after the TBI, they made clinically and personally significant improvement in impairment, function, and life role participation, beyond gains shown from standard care.

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Poster 86

Sensory processing and sensory augmentation for balance control in chronic post-concussive syndrome.

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Although postural instability is one of the most common and debilitating complaints in post-concussive syndrome (PCS), we currently lack sensitive, objective measures that characterize postural deficits with sufficient specificity to guide rehabilitation. The goals of this study are to 1) explore sensory processing strategies for balance control in PCS subjects and 2) explore if augmentation of sensory information improves balance in people with PCS.

Methods:

Pilot study 1: Three subjects with PCS were measured on dynamic characteristics of sensory contributions to balance control. Body sway was evoked by continuous, wide bandwidth rotations of either the stance surface or visual surround at 3 different stimulus amplitudes. Center of mass sway data were analyzed using Fourier methods to calculate frequency response functions (FRFs) expressed as gains and phases as a function of stimulus frequency. Parameters of a previously developed feedback control model were adjusted to provide an optimal match to the experimental FRF data. The model's parameters included 1) percent sensory contributions of visual or proprioceptive information and 2) neural controller parameters (the strength of the sensory-to-motor transformation). Response measures were compared to normative data from 12 subjects.

Pilot study 2: Four subjects with PCS received auditory biofeedback (ABF) training using an inertial sensor synched to an ABF device to provide information on postural sway under varying sensory conditions. Specifically, subjects were asked to stand quietly for 30 seconds, first without and then with ABF. Percent changes in sway area ($(SA-SA_{ABF}/SA)*100$) during ABF compared to non-ABF trials were reported.

Results:

Pilot study 1: Two of 3 subjects had difficulty utilizing visual information for balance control. During stance on a fixed surface, visual stimuli evoked greater sway in these 2 subjects compare to normal subjects. Results also showed that these same 2 subjects had a reduced ability to use visual information to suppress sway evoked by rotation of the stance surface. Specifically, in response to surface rotations, FRF gains were as large when subjects viewed a stationary visual scene as when they had their eyes closed.

Pilot study 2: Subjects showed a mean decrease of 43% (±35) sway area using ABF compared to non-ABF while standing with feet together on a firm surface ($p=0.09$) and a significant mean decrease of 50.3% (±29) sway area using ABF compared to non-ABF while standing with feet together on foam ($p=0.04$).

Conclusion: Large sway may indicate decreased ability of the nervous system to detect, centrally process and/or correct postural sway. People with PCS may have a maladaptive strategy for balance control particularly with regard to using or ignoring visual information. Postural sway was decreased in people when ABF was provided. These preliminary results suggest that ABF may be beneficial for rehabilitation of balance control in this population.

Poster 87

Educate, Train, Treat, Track: Bringing State of the Art Care to our Military with Traumatic Brain Injury

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A poster describing the U.S. Army Traumatic Brain Injury (TBI) program. Displays progress from the U.S. Army TBI Task Force. Also includes capabilities and services in the deployed and garrison environments within the context of Department of Defense (DoD) policy for TBI care and existing gaps within the system. Shows the evolution of, and current, policies and clinical algorithms in the deployed and garrison environments as well as DoD clinical recommendations. Poster includes the Neurocognitive Assessment Tool and role of neurocognitive assessment in return to duty decision making. Presents the DoD TBI coding procedures and challenges in analyzing coded data. Shows Army TBI Research initiatives related to TBI. Finally, displays the Army TBI education and training strategies used to educate a widely-dispersed population of medical staff and providers and specific tools and resources developed to support the TBI mission to include patient education handouts, multi-media educational tools and slide decks, and the TBI Rehabilitation ToolKit.

Poster 88

Creatine Monohydrate as a neuroprotective supplement for mild traumatic brain injury

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Alterations in brain metabolites after traumatic brain injury (TBI) suggest a period of metabolic vulnerability occurs following the initial trauma, which may persist despite an absence of symptoms and normal appearance of brain structure. However, when subjected to metabolic stressors after injury the brain appears to be incapable of restoring energetic homeostasis and measurable neuropsychological deficits emerge.

Creatine is a naturally occurring compound involved in the buffering, transport and regulation of cellular energy. Dietary creatine supplementation has been associated with improved symptoms in neurological disorders defined by impaired neural energy provision. Creatine is also neuroprotective in vitro against anoxic/hypoxic damage. The utility of creatine supplementation to protect against energetic insult in vivo remains to be investigated in humans.

We present data from healthy individuals who underwent oral creatine supplementation (or placebo control) and neurophysiological and neuropsychological assessment during acute oxygen deprivation - a metabolic stressor that induces energy crisis and cognitive symptoms similar to those which occur following TBI. We also present pilot data from patients with mild TBI.

The healthy volunteers participated in a week-long placebo-controlled creatine monohydrate supplementation protocol within a double-blind, crossover design. Creatine concentration in the sensorimotor cortex was on average 9.2% greater following supplementation (Cr: 7.0 ± 1.6 mmol/L, Pla: 6.4 ± 0.9 mmol/L; $p = 0.04$) as measured using magnetic resonance spectroscopy. A hypoxic gas breathing protocol severely reduced arterial oxygen saturation (SaO_2, Cr: 79 ± 8%, Pla: 79 ± 11%; $p < 0.01$) and impaired a wide range of neuropsychological processes consistent with common symptoms of mild TBI. A composite neurocognitive index score was reduced by 12 ± 20% ($p = 0.02$). Impairments were most pronounced for measures of attention (complex attention: -29 ± 55%; $p = 0.03$). Corticomotor excitability increased in response to hypoxia with creatine supplementation (Δ ΣMEP, Cr: 170 ± 91% vs. Pla: 127 ± 60%; $p = 0.04$) and restored hypoxia-induced decrements in neuropsychological performance (neurocognitive index -4 ± 12%, complex attention: -8 ± 18%).

Deficits in cognitive function that occur during oxygen deprivation are consistent with dysfunction in frontal and hippocampal neural circuits, similar to injury that occurs with mild TBI. Creatine appears to be neuroprotective toward these deficits, perhaps as a result of a neuromodulatory action when cellular energy provision is compromised.

Dietary creatine monohydrate supplementation augments neural creatine, increases corticomotor excitability, and prevents decline in cognition that occurs during severe oxygen deficit and energy crisis. Seven days of creatine monohydrate supplementation has potential utility as a neuroprotective supplement in those recovering from mild TBI.

Poster 89

ASSESSING MOTOR PERFORMANCE FOLLOWING mTBI IN MILITARY SERVICE MEMBERS USING BODY WORN INERTIAL SENSORS

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Introduction: Assessing a military service member's (SM) return-to-duty readiness is required after a suspected mild traumatic brain injury (mTBI) has been sustained in order to ensure proper medical treatment is provided and to prevent further injury from occurring.

Purpose: The purpose of this study is to use body worn inertial sensors to develop a nonlinear dynamic analysis that can characterize functional motor performance between mTBI patients and healthy controls to assist with return-to-duty readiness decisions for military SMs.

Methods: Healthy control volunteers were recruited from UNC ROTC cadets and US Army active duty SMs stationed at Fort Bragg, NC with no prior history of mTBI. mTBI subjects were recruited from US Army active duty SMs at Fort Bragg who have received treatment for mTBI at Womack Army Medical Center. The subjects are instructed to perform the Illinois Agility Test (IAT) which involves running 30 feet with rapid directional changes and navigation of serpentine obstacles that require agility and dynamic stability. Inertial sensor data is collected from two tri-axial accelerometers mounted on the subject's head and torso. Acceleration measurements were plotted in a phase space portrait using Matlab.

Results: This study is still in the data collection phase but preliminary data analysis has shown differences in the shape and size of phase space portraits generated by the inertial sensor acceleration data collected from mTBI patients and healthy controls.

Conclusion: The use of nonlinear dynamic methods such as phase space portraits can help detect subtle differences in motor performance and gait instability during high-level mobility tasks such as the IAT.

Clinical Relevance: In combination with a battery of other motor and cognitive tasks including those utilizing a dual task paradigm, nonlinear dynamic methods such as phase space portraits can help reveal motor performance differences in different subject populations that may be difficult to detect using traditional clinical measures. These quantitative measurements can aid clinicians in increasing the reliability of return-to-duty readiness decisions following suspected mTBI cases in military SMs.