Impact of a Conductive Education intervention on supraspinal structures in adults with chronic stroke

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Introduction

The location and severity of damage to the brain after a stroke influences the extent of functional limitations experienced by the stroke survivor[1]. After injury, measurable physiological changes continue that can be correlated with functional clinical measures[2]. With physical rehabilitation interventions, functional impairments can be lessened, presumably through mechanisms of neuroplasticity. Though interventions are often effective for restoring at least partial function for individuals with stroke, little is known about what underlies the positive results for specific interventions.

The **purpose** of this pilot study was to assess changes in neurological structure and connectivity in adults with chronic stroke after participation in a novel cognitive-physical rehabilitation intervention program known as Conductive Education (CE).

CE is a multidisciplinary, motor-learning based intervention which uses multimodal facilitations including manual facilitation, equipment, rhythmic intention (a cadence facilitation), first person verbal articulation, and the group environment[3]. An aim of this pilot study was to replicate and expanded upon a previous study examining the potential of CE as an intervention for adults with chronic stroke[4].

Subjects and Methods

All research protocol were performed with the approval of the GSU IRB.

Study Design:

- Pre-test/Post-test quantitative analysis of functional outcome measures and measure of gray matter density and connectivity

Subjects:

- Four adults with chronic (>6mo) stroke; 1F, 3M
- All subjects had completed outpatient rehabilitation at least 5yrs prior
- All subjects had persisting physical impairments
- Lesions: pontine-level (n = 2/4); subcortical (n = 2/4)

Outcome measures

- Measures of function (via clinical assessment by licensed PT)
  - Stroke Impact Scale, Barthel*, TUG*, 10mWT*
- Supraspinal neurological structure and connectivity (via imaging, hi-res, 3T Prisma magnet, 64 channel head/neck coil)
  - Gray matter assessment (MRI T1 scans, voxel-based morphometry)
  - White matter assessment/myelin concentration (DTI/MT scans)
  - Network connectivity between gray matter regions (resting fMRI)

Intervention

- Conductive Education Program
- Weekly, 2-hour CE program sessions for 10 weeks.

Pre-test	Conductive Education	Post-test
Clinical evaluation, MRI/DTI	10 Weeks →	Clinical evaluation, MRI/DTI

Analysis

- Pre/post intervention changes in outcome measures and imaging
- Outcome measure assessed for Minimally Clinically Important Differences (MCID)
- Imaging analysis
  - VBM 8 on SPM12 used to segment structural images to gray matter, white matter and CSF tissues.
  - Segmented images modulated, normalized to MNI space; resulting images preserved for the total amount of tissue
  - Normalized gray matter images smoothed with 8 mm FWHM Gaussian kernel
  - Pre-training image subtracted from post-training image; resulted image presents the GM changes in each voxel

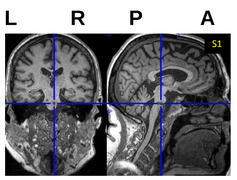
*Performed but not reported here

Results

Participants demonstrated individualized increases in gray matter density, consolidation of connectivity, and functional improvements after the 10 week Conductive Education Program.

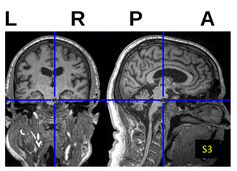
Lesion
L = left, R = right,
P = posterior, A = anterior

Subject 1 (F)



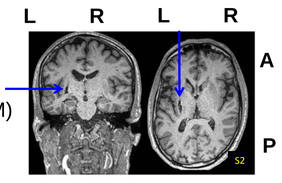
S1 Lesion: Right Pons

Subject 3 (M)



S3 Lesion: Right Pons

Subject 2 (M)

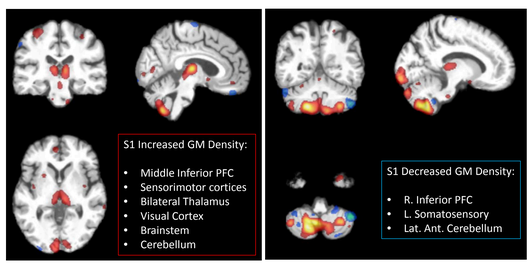


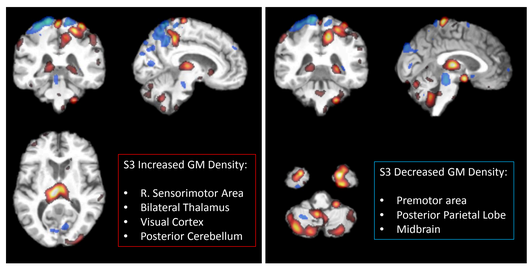
S2 Lesion: Left Putamen/ Internal Capsule

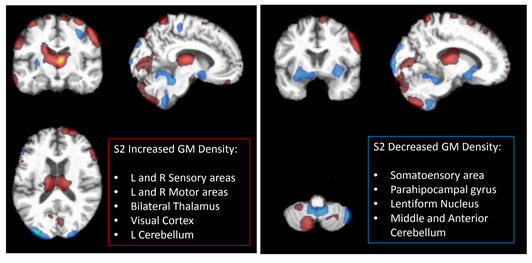
Subject 4 (M)

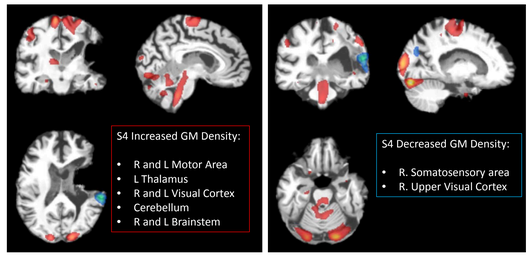
S4 Lesion: Right Hemisphere

Gray Matter (GM) Density changes
Red = increase, Blue = decrease



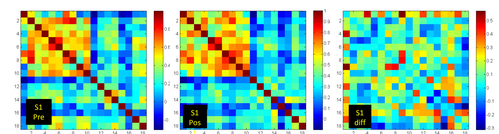






Connectivity changes
Between gray matter regions
Red = increase, Blue = decrease

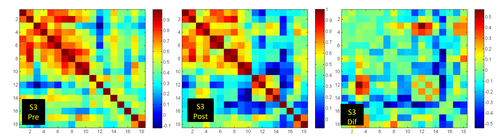
Pre-intervention Post-intervention Difference



S1 Large changes in connectivity (incr. post intervention) between:

- M1 L and M1 R
- M1 L and SMA R
- M1 L and SMA L
- M1 R and SMA L

Pre-intervention Post-intervention Difference



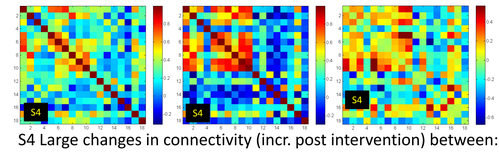
S3 Large changes in connectivity (incr. post intervention) between:

- M1 L and M1 R
- M1 L and S1 L
- M1 R and SMA R

Gray matter region key:

1. Precentral_L	10.Paracentral_Lobule_R
2. Precentral_R	11.Caudate_L
3. Rolandic_Oper_L	12.Caudate_R
4. Rolandic_Oper_R	13.Putamen_L
5. Supp_Motor_Area_L	14.Putamen_R
6. Supp_Motor_Area_R	15.Pallidum_L
7. Postcentral_L	16.Pallidum_R
8. Postcentral_R	17.Thalamus_L
9. Paracentral_Lobule_L	18.Thalamus_R

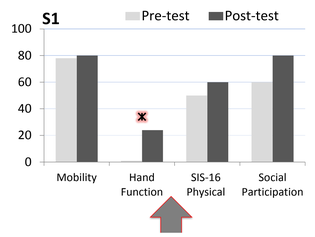
Pre-intervention Post-intervention Difference



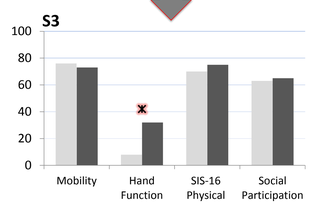
S4 Large changes in connectivity (incr. post intervention) between:

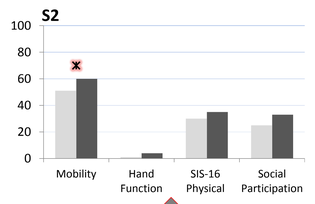
- M1 L and M1 R
- S1 R and SMA R
- M1 R and SMA R
- M1 R and SMA L
- SMA R and SMA L
- Overall consolidation

Functional changes
Stroke Impact Scale (SIS, range 0-100)
Meets of exceeds Minimally Clinically Important Difference (MCID)

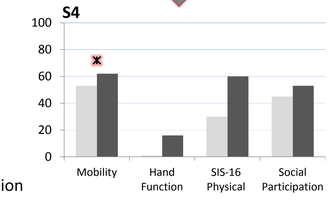


Subjects with pontine lesions (S1 & S3) demonstrated >MCID improvements in SIS Hand Function





Subjects with subcortical lesions (S2 & S4) demonstrated >MCID improvements in SIS Mobility



Conclusions and Future Aims

- From this pilot study, we conclude that a CE intervention could be effective for adults with chronic stroke by inducing supraspinal changes measurable with emerging imaging techniques
- Similar to lesion location and severity, structural and functional gains were unique to the individual
  - Overall, stronger neural connectivity and increases in gray matter in the motor cortex, thalamus, and visual cortex, important regions for execution of movements, control of motor task planning and initiation, and origin of visual streams for visuo-motor coordination
  - Similar to studies by Brown and others[4], participants showed functional improvements post CE
- Future Aims: seeking funding for expanded study with larger sample size and controlling for non-intervention- related changes over time.

References and Acknowledgements

References:

1. Partridge & Morris. Clinical Rehabilitation (1993) 7:210-217
2. Kalinosky et al.. NeuroImage: Clinical (2013) 2:67-781
3. Bourke-Taylor, et al. Phys and Occup Ther in Pediatrics (2007) 27(1): 45-62
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