Upper Limb Motor Coordination Assessment in Patients with mild TBI in a Clinical Setting

Greffou, Selma, Ph.D.
Leonard, G., Ph.D.
Tinawi, S., M.D.
Bélanger, A.M., M.Sc.c.
Valle-Mena, R., B.Sc.c
Feyz, M., M.Sc.

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Manual Gross Motor Coordination

- **Motor coordination**: body’s activation of the proper muscles required for purposeful, controlled, accurate and quick movements

- Involved in every day life tasks of varying complexity

- Require interaction between different neural networks
Voluntary Movements in the Brain

**Motor cortex:**
- Primary motor cortex
- Premotor area (PMA)
- Supplementary motor area (SMA)

**Other cortical areas:**
- Prefrontal cortex
- Posterior parietal cortex

**Subcortical areas:**
- Basal Ganglia
- Thalamus

**Cerebellum**
Leonard Tapping Task (LTT)

Based on Thurstone’s Two-Hand Coordination task 1949: ability to do 2 things simultaneously (part of an intelligence test)
LTT
1. Unimanual Sequential Tapping
2. Bimanual in-phase Tapping
LTT

3. Bimanual out-of-phase Tapping
LTT
4. Rapid Tapping
LTT Data Extraction

- Device connected to a computer via a USB cable
- Computer records every correct taps and errors
- **Total Score** = number of correct taps – errors
- Total Score is averaged across 2 trials and compared to norms for the age and gender (z-scores)
PET study
Unimanual Sequential – Rapid Tapping

Left hand

Right hand

Bélanger, et al. (2015)
PET study
Bimanual Sequencing - Unimanual Sequencing

In phase

Out of phase

Bélanger, et al. (2015)
PET study
Bimanual out-of-phase – Bimanual in-phase

Bélanger, et al. (2015)
mTBI and Motor Coordination

- mTBI children had balance problems but excelled on upper limb coordination tasks on BOT-2 test (Gagnon et al., 1998)

- Motricity-related brain changes in animal models of mTBI (Wang et al., 2014; Yang et al., 2013)

- Functional changes in the brain associated with motor control and coordination in athletes suffering from mTBI (Slobounov et al., 2002)

- Female concussed athletes showed deficits in motor coordination (Beehler, et al. 2007)
Motor coordination problems often self-reported by our patients (e.g., cooking) but...no objective measure except brief neurological examination

**Goal**: objectively measure complex manual gross motor coordination in patients with mTBI as part of a neurocognitive battery of tests → helps guide care
METHODOLOGY
Participants

- Montreal General Hospital TBI Program (Outpatient Clinic)
- Patients with diagnosed mTBI by the same physiatrist
- $N = 38$
- Females $n = 21$ / Males $n = 17$
- Age range: 16 to 52 years
- Time post-injury: 12 to 168 days
- No documented premorbid psychiatric history
- Assessment with a neurocognitive battery
Administered Neurocognitive Tasks

- Post-traumatic symptoms scale (PCS-R)
- Abbreviated IQ: Visual Reasoning + Verbal Reasoning (WASI-II)
- Visual Memory (Rey Complex Figure)
- Verbal Memory (CVLT-II)
- Auditory short-term memory + working memory (WAIS-III)
- Visual scanning and alternating between targets (TRAIL A + B)
- Processing speed of visual informations (PSI WAIS-III)
- Verbal Fluency (D-KEFS)
- Fine manual dexterity (Grooved Pegboard)
- Planning and strategy formation (TOL)
- Anxiety symptoms (BAI)
- Depression symptoms (BDI-II)
## Preliminary Results

### Descriptive statistics

**Percent of patients with weak to impaired performances**

<table>
<thead>
<tr>
<th>LTT Experimental Condition</th>
<th>Percent N in Low-Average range</th>
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</thead>
<tbody>
<tr>
<td>Unimanual Sequencing Tapping DH</td>
<td>47 %</td>
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<tr>
<td>Unimanual Sequencing Tapping NDH</td>
<td>45 %</td>
</tr>
<tr>
<td>Bimanual in-phase Tapping</td>
<td>45 %</td>
</tr>
<tr>
<td>Bimanual out-of-phase Tapping</td>
<td>45 %</td>
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<tr>
<td>Rapid Tapping DH</td>
<td>42 %</td>
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<tr>
<td>Rapid Tapping NDH</td>
<td>37 %</td>
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Preliminary Results
Significant Pearson Correlations ($p \leq 0.01$)

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Unim D</th>
<th>Unim ND</th>
<th>Bim IP</th>
<th>Bim OP</th>
<th>Rapid D</th>
<th>Rapid ND</th>
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<tbody>
<tr>
<td>Unimanual D</td>
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<td>0.91</td>
<td>0.77</td>
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<td>0.78</td>
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<td>Bimanual out-phase</td>
<td>0.54</td>
<td>0.58</td>
<td>0.79</td>
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<td>Rapid D</td>
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<td>Rapid ND</td>
<td>0.46</td>
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# Preliminary Results

Significant Pearson Correlations ($p \leq 0.01$)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Rapid</th>
<th>Rapid</th>
<th>Unim</th>
<th>Unim</th>
<th>Bim</th>
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<tr>
<td></td>
<td>D</td>
<td>ND</td>
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<td>ND</td>
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<td>OP</td>
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<tr>
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<td>Visual Reasoning</td>
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<td>Verbal Memory</td>
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<tr>
<td>Auditory Short-Term Memory</td>
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<td>Planning initiation time</td>
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<td>Time post-injury</td>
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</table>
Early Findings Interpretation

Some patients have difficulties with motor sequencing and/or motor speed.

Experimental conditions: ↑ complexity of motor ability as correlated with other neurocognitive measures:

- **PET study**: different conditions sollicit a different number of cortical areas (Bélanger et al., 2015)
In our study, mTBI performance on Bimanual out-of-phase condition was the only one correlated with that on a planning task (TOL).

Bélanger, et al. (2015)
• **Frontal lobe lesions (LTT study):** frontal lobe plays a critical role in the coordination of hand and arm movements, particularly when different movements have to be performed simultaneously (Leonard et al., 1987)

• **Frontal-lobe foci epilepsy (LTT study):** impaired Bimanual out-of-phase Tapping vs. controls but no differences for temporal foci epilepsy vs. controls confirming the role of frontal cortex in complex coordination of the two hands (Crane et al., 2013)
mTBI and the Frontal Lobe

→ Meta-analysis of 122 brain imaging studies (Eierud et al., 2014):

- **Functional MRI**: decreased blood flow in frontal regions

- **Diffusion MRI (DTI)**: abnormal direction of water molecules diffusion in frontal regions

- **Electrically Evoked Potentials (EEG)**: electrical response of neuronal populations is slower and lower in intensity
Diffuse Brain Insults Hypothesis

- **Diffuse foci epilepsy (LTT study):** impaired on the Unimanual Sequential Tapping conditions with either hand. Some difficulty on Bimanual in-phase Tapping; may reflect slower hand movements in this group (Crane et al., 2013)

- **mTBI:** diffuse brain injury often reported, e.g., axonal micro-shearings, neurometabolic alterations.

- In this preliminary study, low performances for all conditions
Specificity of the LTT

- LTT not significantly correlated with fine manual dexterity
- LTT not significantly correlated with PCS-R post-traumatic symptoms scores
- LTT is an informative and distinct motor measure and tends to be associated with other neurocognitive difficulties
- Most complex condition associated to time post-injury, sensitive to neurological recovery?
Clinical Implications

- Corroborates self-reported motor coordination complaints

- Could help clinical management of patients with mTBI for safe return to socio-vocational activities (e.g., manual workers)

- Sensitive across neurological populations (e.g., MS, PD, epilepsy)

- Excellent test-retest reliability ($r \sim 0.80$)

- Fast to administer (10 minutes)
Future Directions

- Increase the sample size
- Association with specific symptoms, e.g., fatigue, headaches
- Look into comorbidities and how they also influence findings (e.g., migraines, thyroid dysfunction, PTSD, etc…)
- Study motor learning curve (Trial 2 vs. Trial 1) in mTBI patients
- Compare our findings with that in children with mTBI (ongoing study)
- Study the LTT in other severities of TBI
THANK YOU!

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Dr. Reza Farivar
References

References


