Neurofeedback Enhanced by Electromagnetic Closed Loop-EEG© using Complex Adaptive Modality® Improves Hand Control Movement in a Case of Essential Tremor

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ElectroMagnetic Neurofeedback & Essential Tremor - a case study

Essential tremor (ET) is an involuntary shaking, usually of hands, and has no satisfactory treatment yet.

ET affects more than 1/100 people of the general population, climbing to 4/100 among people over 40 years old.
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- The neural mechanism underlying ET is still unknown.
- One hypothesis is that ET may be result from a defective mechanism that normally dampens the natural oscillation of the inferior olive (IO) neurons.
- The presence of low threshold calcium channel (LTCC) in IO are responsible for its oscillatory activity.
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Projections to the cerebellum showing the inferior olive (IO)
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- A 74 year old retired woman with a 24-year history of essential tremor (ET) came to our office for biofeedback.

- Her tremor had not been successfully treated
  - by medications:
    - Inderal, Corgard, Blocadren, Neurontin, Mysoline, Nitroglycerin, Tranxene, Clonazepam, Melatonin, Methazolamide, Melatonin, and Antihistamines, or
  - by Acupuncture.

- Some medications produced greater side effects than benefits.
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Personal Medical History

- Patient suffered from chronic allergies since childhood and treated with anti-histamines.

- Her tremor started 24 years ago, but it was aggravated by a ski accident (6 years ago), and hip replacement surgery followed by a hip dislocation due to physical therapy.
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Medical Information at the intake:

- During the first visit the patient reported that she took Benadryl for allergies for more than 55 years, and was also on, Ginkgo biloba, and multivitamins.

- Other symptoms: tinnitus
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- **Pre biofeedback training** The Test of Variables of Attention (TOVA) was in the normal range for her age.

- **Electro-encephalography (EEG)** evaluation performed on a Neurocybernetics instrument showed great variability, predominantly at the C3 position, spikes, and very slow and rhythmic activity.

- **Quantitative EEG** remains to be done.
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- The EEG evaluation on the Roshi instrument showed right and left brain waves out of phase, and low synchronization, based on the original neural efficiency (NE=60 at C3/ C4, and NE=47 at P3/ P4).

- Psycho-physiological profiling and forearm-to-forearm muscle testing, performed on a Biocomp instrument, showed a direct correlation between emotions and tremor.
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Training observations:

The tremor was not affected by Single channel monopolar Neurofeedback training, or by Left/Right Neurofeedback enhanced by light-closed loop-EEG ©(NF-LCL-E)

See session 3 and 4
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Positive Training Observation

- The patient's tremor did diminish significantly after the first session on a Roshi instrument after Neurofeedback training at C3/C4 positions enhanced by electromagnetic closed loop-EEG©(NF-EMCL-E) using complex adaptive modality.
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Positive observations

- This positive effect was repeated in the sessions which followed and done at C3/ C4 or P3/ P4 positions.
- See sessions 2, 3, 5, 6, 7, 8, 9, and 10.

Monitoring progress:

The changes in the right hand motion were monitored through drawing (Archimedes spirals) and writing samples (name & numbers) collected pre-training, post NF and post NF-EMCL-E© training.
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**Important Note:**

The gain obtained after each NF-EMCL-E© seemed to be affected in negative way by the use of antihistaminic meds. Benadryl type meds were taken only after each session, but not before. Patient took anti-histamines for more than 55 years, at a 3 times a day regimen!

The gains from NF were more stable when Benadryl was stopped.
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Classification of tremors by:

- Frequency
- Distribution or location
- Diurnal variation
- Rest or motion induced
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### Differential Diagnosis of tremor

<table>
<thead>
<tr>
<th>Cause</th>
<th>Appearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerebellar</td>
<td>Intention</td>
</tr>
<tr>
<td>Essential</td>
<td>Action/ sustentation</td>
</tr>
<tr>
<td>Parkinsonian</td>
<td>Resting</td>
</tr>
<tr>
<td>Physiological</td>
<td>Action/ sustentation</td>
</tr>
<tr>
<td>Rubral</td>
<td>Action/ resting</td>
</tr>
</tbody>
</table>
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- Etiologies of Tremor
  - Physiologic tremor
  - Primary tremor or essential tremor (ET)
  - Symptomatic or secondary tremor
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<table>
<thead>
<tr>
<th>Drug-Induced Tremor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Class</strong></td>
</tr>
<tr>
<td>Beta-adrenergic agonists</td>
</tr>
<tr>
<td>Dopamine agonists</td>
</tr>
<tr>
<td>Amphetamine</td>
</tr>
<tr>
<td><strong>Examples</strong></td>
</tr>
<tr>
<td>Metaproterenol</td>
</tr>
<tr>
<td>Terbutaline</td>
</tr>
<tr>
<td>Epinephrine</td>
</tr>
<tr>
<td>Levo-dopa</td>
</tr>
</tbody>
</table>
# ElectroMagnetic Neurofeedback & Essential Tremor - a case study

## Drug-Induced Tremor

<table>
<thead>
<tr>
<th>Class</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Psychiatric drugs</td>
<td>Tricyclic antidepressants, Neuroleptics, Lithium</td>
</tr>
<tr>
<td>Anticonvulsants</td>
<td>Sodium valproate, Carbamazepine</td>
</tr>
</tbody>
</table>
# ElectroMagnetic Neurofeedback & Essential Tremor - a case study

## Drug-Induced Tremor

<table>
<thead>
<tr>
<th>Class</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endocrine drugs</td>
<td>Thyroxine</td>
</tr>
<tr>
<td></td>
<td>Hypoglycemic</td>
</tr>
<tr>
<td></td>
<td>Andrenocorticosteroids</td>
</tr>
<tr>
<td>Drugs used in neuroimaging</td>
<td>Metrizamide</td>
</tr>
<tr>
<td>Methylxanthines</td>
<td>Coffee, tea, colas</td>
</tr>
<tr>
<td>Other drugs</td>
<td>Cimetidine</td>
</tr>
<tr>
<td></td>
<td>Monosodium glutamate</td>
</tr>
<tr>
<td></td>
<td>Antihistaminics**</td>
</tr>
</tbody>
</table>
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Symptomatic Treatments for ET

<table>
<thead>
<tr>
<th>Medication</th>
<th>Brand Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mirtazapine</td>
<td>Remeron</td>
</tr>
<tr>
<td>Gabapentin</td>
<td>Neurontin</td>
</tr>
<tr>
<td>Primidone</td>
<td>Mysoline</td>
</tr>
<tr>
<td>Propranolol</td>
<td>Inderal</td>
</tr>
<tr>
<td>Nadolol</td>
<td>Corzide</td>
</tr>
<tr>
<td>Metoprolol</td>
<td></td>
</tr>
</tbody>
</table>
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Some diagnostic tests for tremor:

- Drug or toxicology screen
- T4, TSH
- ANA, ESR
- Copper and ceruloplasmin
- Glucose and electrolytes
- Head MRI
- QEEG
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Some historical data related to the use of electromagnetic field therapy:

The use of electromagnetic field pulsed therapy in Parkinson’s disease (PD) was reported the first time in 1992 by Sandyk, in Intern. J. Neuroscience.
Until today, Sandyk published a large number of articles showing the positive responses to electromagnetic fields in PD, such as improvement in word-fluency (1994), in speech impairment (1997), reversal of body image, or reversal of the bicycle drawing direction (1998).
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In our practice we use NF coupled with light or electromagnetic stimulation. In the last two years we presented positive results with some of our patients: in a case of chronic pain, and Parkinson’s Disease (PD) post traumatic brain injury (TBI), in cases of paralysis post TBI (CVA or post-accident) and in cases of cardiac arrhythmias.

## ElectroMagnetic Neurofeedback & Essential Tremor - a case study

<table>
<thead>
<tr>
<th>Session</th>
<th>Date</th>
<th>Electrode Position</th>
<th>NF Modality</th>
<th>Instrument</th>
<th>1 Neural Efficiency</th>
<th>2 Neural Efficiency</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11/30/00</td>
<td>C3,C4,Cz evaluation Cz training</td>
<td>Cz SMR NF</td>
<td>NeuroCyb</td>
<td>NA</td>
<td>NA</td>
<td>Stationary</td>
</tr>
<tr>
<td>2</td>
<td>12/13/00</td>
<td>C3 &amp; C4</td>
<td>1 Sync/ EMCL©</td>
<td>ROSHI</td>
<td>+60</td>
<td>+81</td>
<td>Improved Post 20'</td>
</tr>
<tr>
<td>3</td>
<td>12/18/00</td>
<td>C3 &amp; C4</td>
<td>1 S14/ NF 2 NF-LCL© 3 EMCL©</td>
<td>ROSHI</td>
<td>+2  +3  +3  +3  +5</td>
<td>Improved 10' Degraded 10' Improved 15'</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>12/21/00</td>
<td>C3, F3 &amp; F4/ Fz(r)</td>
<td>1 C3/ SMR NF 2 Sync/ NF-LCL© EMCL©</td>
<td>NeuroCyb ROSHI</td>
<td>NA +40  NA +49</td>
<td>No effect 15' No effect 15' 20'</td>
<td></td>
</tr>
</tbody>
</table>
### ElectroMagnetic Neurofeedback & Essential Tremor - a case study

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<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1/03/01</td>
<td>C3 &amp; C4</td>
<td>1 S14/ EMCL©</td>
<td>ROSHI</td>
<td>+4</td>
<td>+6</td>
<td>Improved 10'/20'</td>
</tr>
<tr>
<td>6</td>
<td>1/05/01</td>
<td>C3 &amp; C4</td>
<td>1 S14/ 2 Sync/ EMCL©</td>
<td>ROSHI</td>
<td>+3</td>
<td>+3</td>
<td>No effect 10’ Min effect 20’</td>
</tr>
<tr>
<td>7</td>
<td>1/08/01</td>
<td>P3 &amp; P4</td>
<td>1 Sync/ NF 2 Sync/ EMCL©</td>
<td>ROSHI</td>
<td>+49</td>
<td>+62</td>
<td>Improved 15’ More Imp 25’</td>
</tr>
<tr>
<td>8</td>
<td>1/09/01</td>
<td>P3 &amp; P4</td>
<td>1 Sync/ NF 2 Sync/ EMCL©</td>
<td>ROSHI</td>
<td>+51</td>
<td>+59</td>
<td>Improved 15’ More Imp 35”</td>
</tr>
</tbody>
</table>
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<tr>
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<th>Date</th>
<th>Electrodes Position</th>
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<th>2 Neural Efficiency</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>1/ 12/ 01</td>
<td>P3 &amp; P4</td>
<td>1AO[E]/ NF 2AO[E]/ EMCL©</td>
<td>ROSHI</td>
<td>+11</td>
<td>+15</td>
<td>Improved 15’ More Imp 15’</td>
</tr>
<tr>
<td>10</td>
<td>1/ 15/ 01</td>
<td>P3 &amp; P4</td>
<td>1AO[E]/ NF 2AO[E]/ EMCL©</td>
<td>ROSHI</td>
<td>+7</td>
<td>+14</td>
<td>Improved 15’ Max Imp* 20’</td>
</tr>
</tbody>
</table>

**Abbreviations:** NF, Neurofeedback; EMCL. Electromagnetic closed loop; LCL, Light closed loop; Sync, synchronization; AO[E], Alpha only enhanced;

**Note:** maximum improvement, able to write pretty well controlled, holding the pencil in between first and second fingers (also observed the relaxation feelings developed after the previous session, and longer time control on tremor)
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11/30/00 Neurocyb EEG Evaluation at C3 position eyes open (EO) eyes closed (EC)
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11/30/00 NeuroCyb EEG Evaluation C4 position eyes open (EO), eyes closed (EC)
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- 11/30/00 Neurocyb EEG Evaluation C3 and C4 Positions, Eyes closed (EC) Depression/Anxiety, Increased Tremor

- C3

- C4
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12-13-2000 Second NF session / 1st session on ROSHI C3/ C4, Sync +60s

I. Pencil between 2nd and 3rd finger
II. Pencil between 1st and 2nd finger
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12-13-2000 Session 2, 1st Roshi, Post NF EMCL-Sync C3/ C4; NE +81e
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12-18-2000 Session 3, 2nd Roshi, at C3 / C4

S14[E]  
Pre NF/ NE +2

NF 10 min/ +3

Post NF-LCL©-E  
10 min/ +3

Post NF-EMCL-E©  
15 min/ +4/ +5
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12-21-00 Session 4, C3-SMR training, or Sync at F3/ F4

Pre NF

Post NF at C3 on NC

Post Sync/ NF
LCL ©F3/ F4
Fz(r)
on Roshi
NE +40s
to +49e
Observe the variability of all the frequencies; There is not too much of a change after the NF
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1/03/01 Session 5, after 12 day break:

C3/C4, S14[E], NE +4s to +6e

Pre NF

Post NF

EMCL©

20 min

Post NF-EMCL©

10 min
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1/5/01 Session 6: C3/ C4, NE (S14, +3s/ e; Sync, + 45s to +60e)

Pre NF

Post S14
10 min

Post Sync
20 min
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1/8/01
Session 7: P3/ P4
Sync: +47s
Post 15 min NF
Sync: +62
Post 25 min
NF-EMCL©
Sync:+74e
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1/9/01 Session 8: P3/ P4 Sync, NE +51s to +67e

Pre NF
NE+51s
Post NF
NF-
EMCL©
15 min
NE +67e

Post NF
15 min
NE +59
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1/12/01 Session 9: P3/ P4 AO[E], NE +11s to +15 after NF; up to +18/ +22 after NF-EMCL©

**First time discussed the Benadryl as a Tremor-inducer and it was stopped!
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1/15/01 Session 10: P3/ P4 AO[E] NE +7s to +14 post NF to +20/ +23 post EMCL©

Post NF
15 min

Post NF - EMCL©
25 min

(First time holding the pencil between 1st and 2nd fingers (not 2nd and 3rd)
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Conclusion

This case demonstrates that NF training enhanced by EMCL-E© using the COMPLEX ADAPTATIVE MODALITY* is beneficial and could even reverse the course of Essential Tremor (ET) in a non-invasive manner.

Keywords: Neurofeedback (NF), Neurofeedback enhanced by electromagnetic closed loop-EEG (NF-EMCL-E©), essential tremor (ET)
* patent pending
ElectroMagnetic Neurofeedback & Essential Tremor

“Freedom is what you do with what’s been done to you.” - Jean Paul Sartre

“Change your brain, change your life.”
- Daniel Amen, M.D.
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