

Neurofeedback in Pain Management

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Neurofeedback in Pain Management

- Definitions:
- Pain is a necessary “evil”.
- or
- “Pain is unquestionably a sensation in a part or parts of body but is always unpleasant and therefore also an emotional experience” (Merskey 1986) *as defined by the International Association for the Study of Pain (IASP).*

Pain Models

- 1. Psychological pain associated with physiological conditions.**
- 2. The bio-psycho-social model of pain.**

Psychological pain is associated with physiological conditions

- Melzak & Wall in 1965, “Gate Theory” of pain.
- This theory incorporated the three systems that are involved in pain experience – sensory-discriminative, motivational-affective and cognitive-evaluative.
- This model integrates the notions that pain can be somatic as well as psychogenic.

Psychological pain is associated with physiological conditions

- The mechanism of pain, incorporating peripheral receptors, pain pathways and cortical and sub-cortical centers where pain is perceived, has brought emphasis to the importance of the corticalization of pain.
- Birbaumer, Flor, Lutzenberger, & Elbert, 1995!

NF, due to CNS neuroplasticity, affects pain perception

- CNS neuroplasticity (Ramachandran & Rogers-Ramachandran, 2000) may explain why Neurofeedback is such a valuable technique.
- Neurofeedback proposes that by teaching self-regulation, a patient can reduce or even eliminate pain sensations.

The bio-psycho-social model of pain

- Gatchel & Turk (1996)
- Craig's statements including the theory on social learning mechanisms (1986).

Table I - Etiology of Chronic Pain of our patients' population

- Head Injuries due to different accidents: STBI, MTBI, CVA
- Work related injuries due to repetitive muscle activities
- Post surgery
- Post inflammation (ie: post shingles)
- Psychological or Idiopathic
- Chronic degenerative diseases

Overview of the complexity of treating chronic pain

The usefulness of BF/NF with co-morbidities associated with chronic pain

- The co-morbidities include high blood pressure and cognitive dysfunctions (Ibric & Grierson, 1995), and sleep disorders (Ibric, 2001).
- The addictive behaviors associated with chronic pain have been addressed with NF, resulting in remarkable success (Ibric 2002; Guyol, 2006).

Table II – Overlapping diagnoses of our patients' population

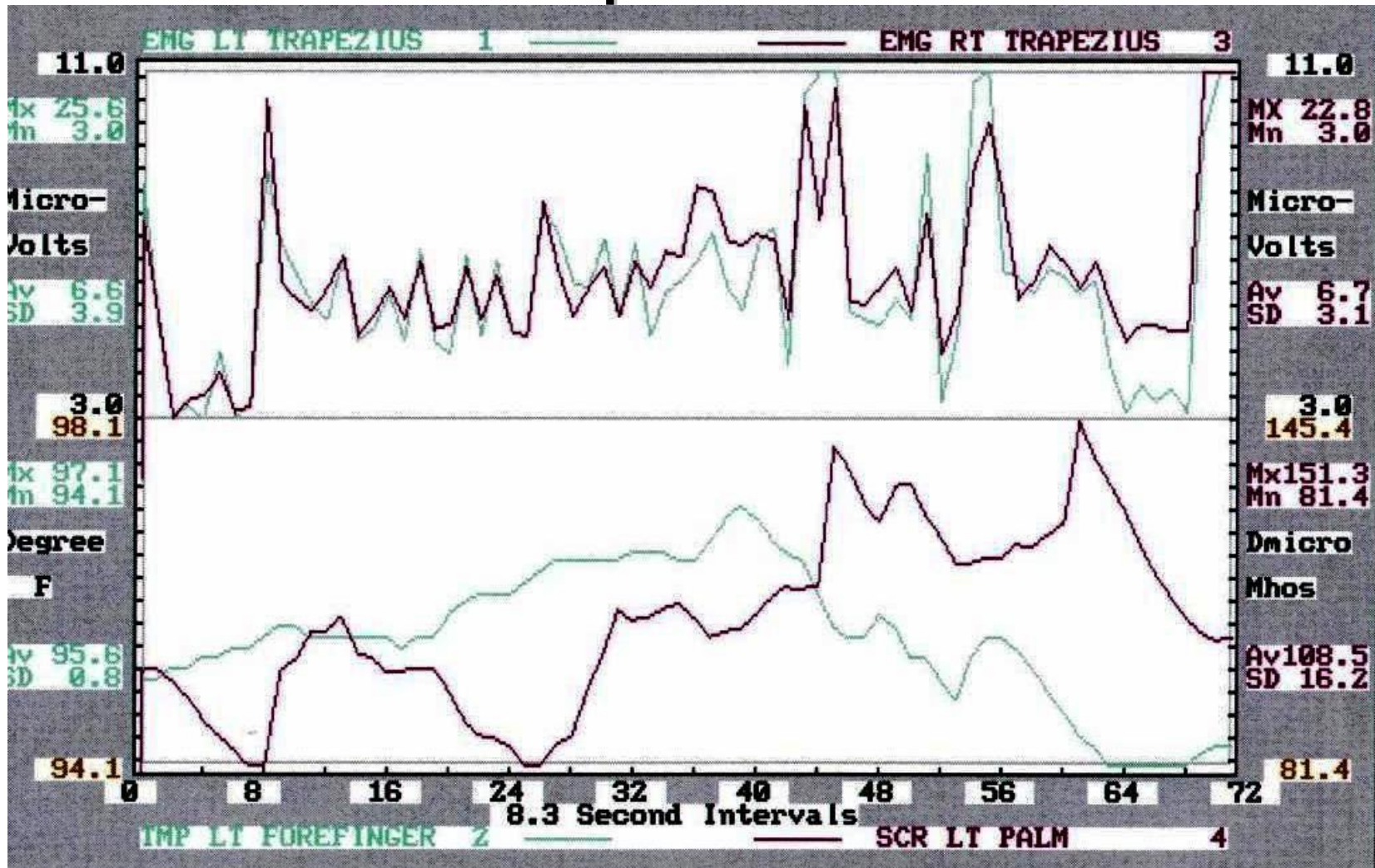
- Anxiety and/or Depression
- ADHD
- Asthma
- Cancer – different localizations
- Essential Tremor or Parkinson's
- Hypertension
- Sleep Disorders
- Memory impairment

Table III – Factors perpetuating and aggravating pain syndromes

1	Mechanical stressors	Structural asymmetry Poor Posture
2	Nutritional deficiencies	Avitaminosis, Poor or imbalanced diet
3	Metabolic and Endocrinologic abnormalities	Hypothyroidism/ Hypoglycemia Hyperuricemia
4	Secondary Psychosocial Factors	Adjustment Disorder Psychosomatic Disorder Secondary Gain
5	Chronic Infections	Bacterial, viral, fungi, etc Immune Deficit Syndromes
6	Sleep Disorders	Sleep Apnea Bruxism
7	Neurologic Disorders	Radiculopathies, Entrapment neuropathies Peripheral neuropathies, Multiple Sclerosis
8	Rheumatologic Disorders	Osteoarthritis, Rheumatoid arthritis, Systemic Lupus Erythematosus

Comprehensive evaluation

Psycho-physiological Profile on Biocomp Instrument



Penfield's Homunculus, 1958

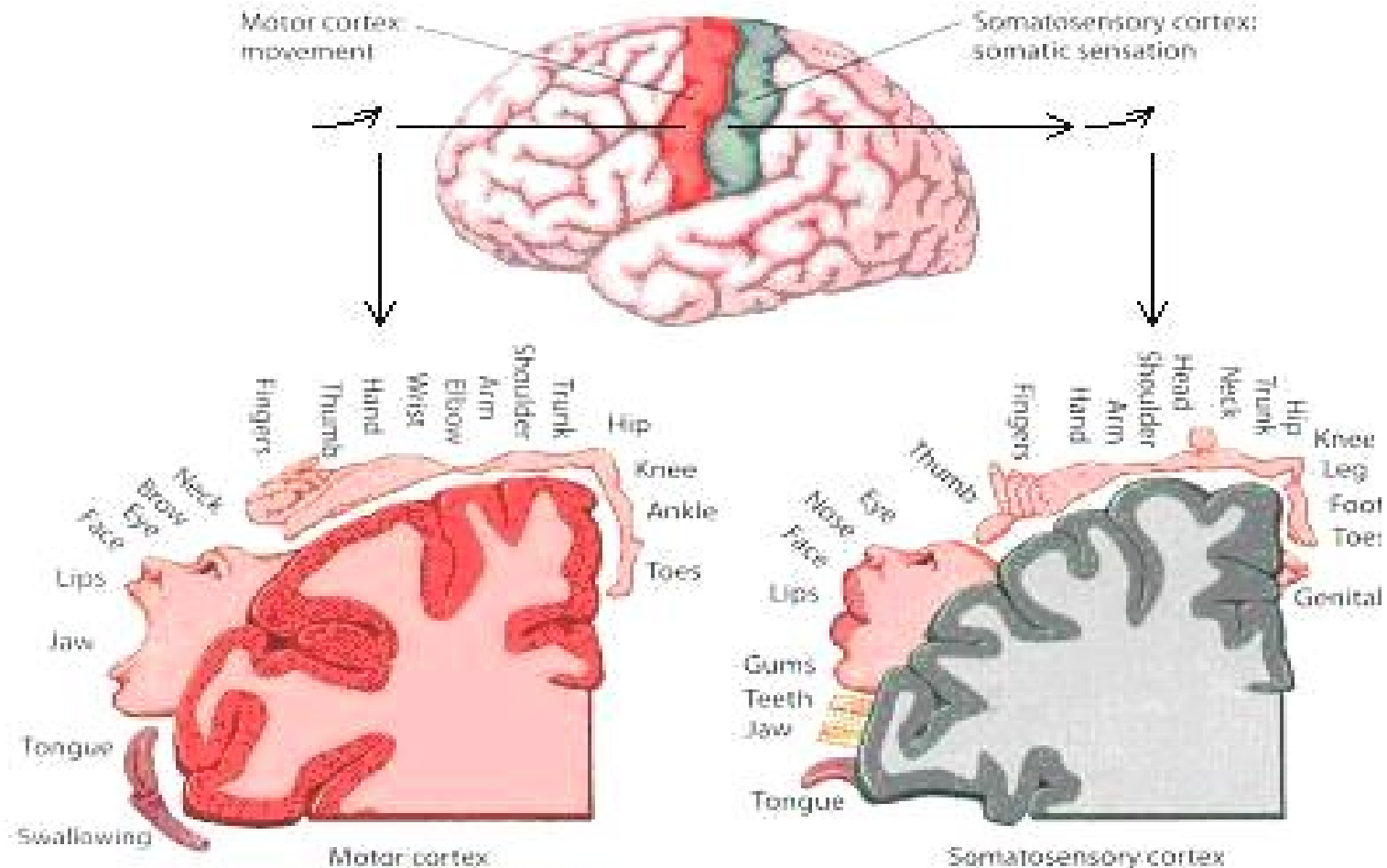


Table IV – The Ten cases presented in detail

Case#	Age	Sex	Main Diagnostic	CO-Morbidities	#NF sessions
1	52	F	RSD Post MVA	Depression, Sleep disorder	15
2	67	F	Headaches, Neck Spasticity post meningitis, Gait dysfunction	Hypertension, Urinary incontinence	145
3	33	M	Neuropathy post TBI & Spinal cord injury due to work accident	Addiction to pain killers	82
4	20	F	RSD left foot	NA	40

The Ten cases presented in detail

Case#	Age	Sex	Main Diagnostic	CO-Morbidities	#NF sessions
5	63	M	Idiopathic Neuropathy	Hypertension	22
6	62	M	Neuropathy post laminectomy	Bipolar Depression, Addiction to pain killers	46
7	35	F	Myofascial pain, Headaches, TMJ	PTSD, Bruxism	16
8	51	F	TMJ/ RSD or Fibromyalgia post MVA	Rheumatoid Arthritis	54

The Ten cases presented in detail

Case#	Age	Sex	Main Diagnostic	Co-Morbidities	#NF sessions
9	60	F	Chronic pain upper/ lower back and legs	Parkinson's Disease, Colon Cancer, Leukemia	56
10	42	M	Left inguinal chronic pain post surgery, mTBI	Kidney stones, Addiction to Pain Killers	112

Case 1

- Case 1 –A 52 y/o female with reflex sympathetic dystrophy (RSD) post MVA, post neck surgery.
- Symptoms: right side face shoulder/ arm, right eye lid spastic ptosis, depression, sleep disorder
- Etiology: MVA 3 years prior to investigating BF
- Other therapies: neck surgery, physical therapy, electrical stimulator implanted
- Medications: Antidepressants, Vicodin

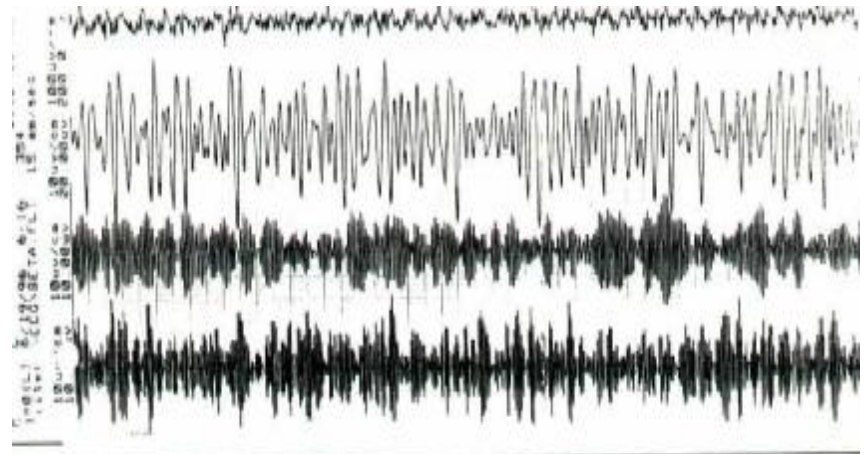
Case 1- Training

- NF training - 15 sessions; NF protocols were done mostly at C3 site {where Beta (15-18 Hz) was enhanced while Theta (4-7 Hz) and High Beta (22-30 Hz) suppressed.}
- Neurocybernetics was the instrument used. The C3 site corresponds to the right eye projection, at the sensory-motor area of the homunculus (see figure).

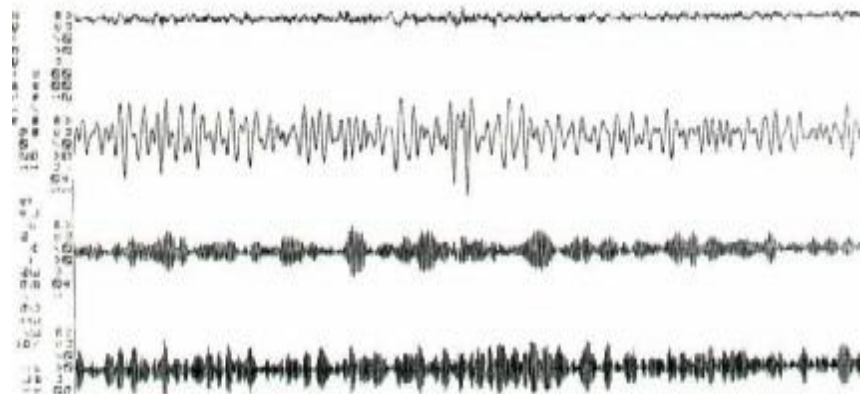
Case 1 – RSD right face, neck/shoulder, during NF session



Before NF training



After 30 minutes NF
On NC



Case 1- Results

- After the first session, the eye stayed opened for 1 hr. As the NF continued, after each session, the same effect occurred as described as in the first session, except that it was sustained for a longer and longer time.
- After 15 sessions, NF training was terminated, due to her family's leaving the state.

Case 2

- Case 2 – A 67 y/o retired actress (recently widowed) with chronic headaches, neck and low back pain; spasticity post meningitis; and hypertension as co-morbidity.
- Symptoms: headaches, right side neck spasticity, gait dysfunction, depression/ anxiety, sleep disorders, memory and concentration impairments, urinary incontinence.

Case 2

- Etiology: Three neck surgeries after an MVA, that occurred 20 years prior investigating BF. Last surgery was done a year before BF and that induced meningitis.
- Other therapies: surgery, psychotherapy, physical therapy, acupuncture,
- Medications: Lorcet, Neurontin, Elavil, Restoril, Depakote, Norvasc, Baclofen, Hydrochlorothiazide, Duragesic patches, Synthroid, Cardura, Norco 10-350, Vitamin B complex, Vitamin E.

Case 2 - Training

- NF training: 145 sessions. Neurocybernetics and ROSHI instruments were used for her NF training. The electrode positioning varied from CZ to C3, or C4, C3-Cz, Cz-C4 and F3/F4, or C3/C4, enhancing either SMR, 15 Hz, or correcting coherence. EEG patterns modified, from a great variability to a more stable activity.

Case 2 - Results

- NF results: Pain perception modified and decreased to none, less depressed or anxious, better and more restful sleep, lowered blood pressure, better gait, and better quality of life. Patient was able to enjoy travel, and moved to a new house, since her husband died.
- Able to reduce her meds by half, under her physician's supervision.

Case 3

- Case 3 –A 33 y/o retired construction engineer, Neuropathy post TBI and spinal cord injury
- Symptoms: Neck, shoulder, upper/lower back, arms, legs pain, spasticity, tremor, gait dysfunction, memory problems, depression, panic attacks, sleep deprivation, neuro-vegetative deregulation (temperature fluctuations with profuse sweats, paroxysmal tachycardia, blood pressure with large fluctuations!), which were exacerbated by Elavil (discontinued).

Case 3

- Etiology: TBI due to work injury that affected the brain stem (post 16 ft ladder-fall)
- Medications: Zoloft, Mirapex, Baclofen, Buspar, Vicodin, Sonata, Ambien, Elavil,

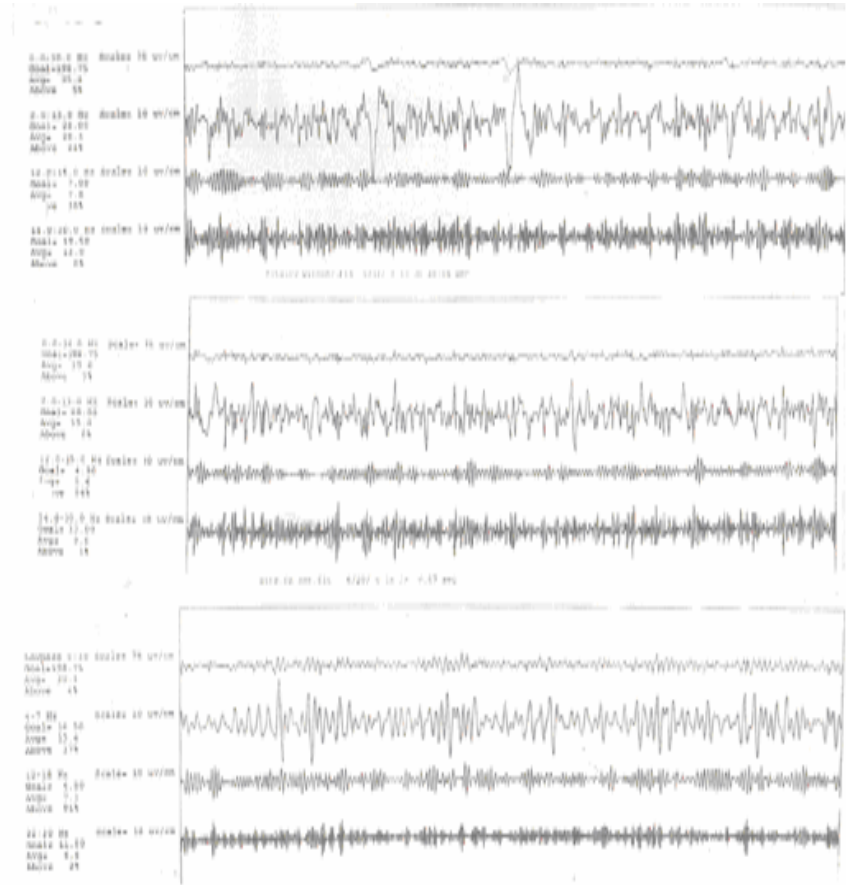
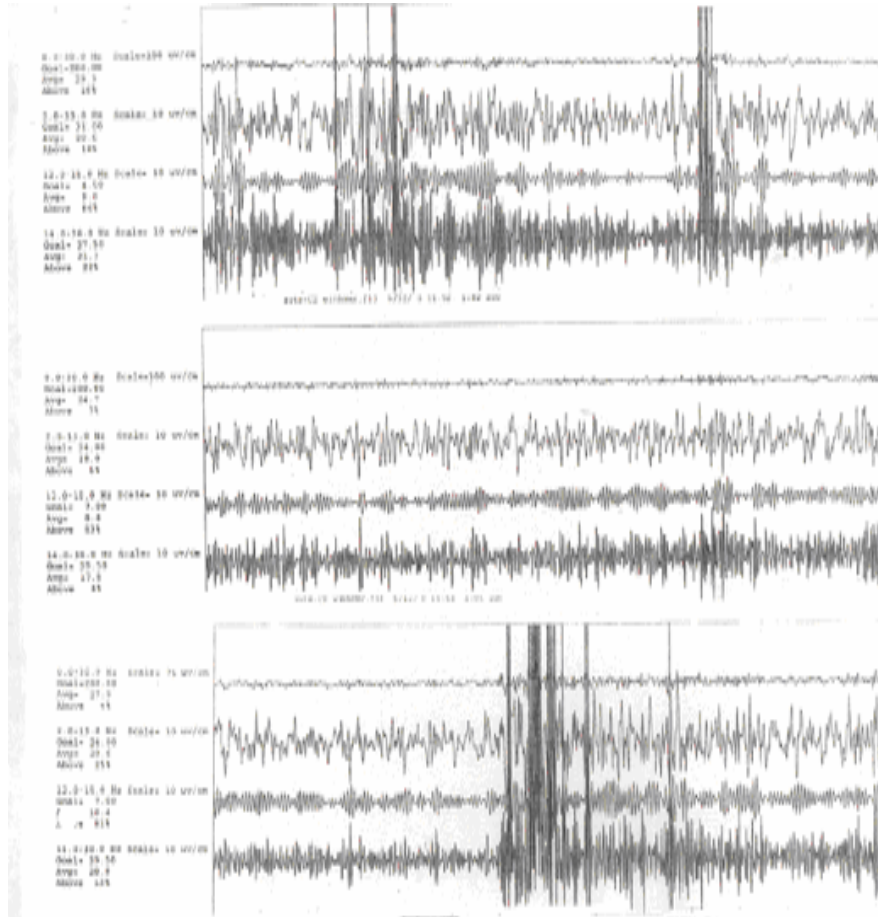
Case 3 - Training

- NF training: 82 sessions
- NF protocols: Number of NC sessions (8) and ROSHI sessions (74)
- Results: decreased pain, tremor and spasticity reduced, less depression, better sleep, reduced medication

Case 3 - Protocols

- The electrodes were placed over the central sensory motor area over the vertex at the Cz position.
- The ROSHI training was set for complex adaptive modality (CAM) for the light stimulation, to inhibit high beta frequency over 25 Hz, or HiBeta [I].
- The effect enhanced by using the electromagnetic stimulation, concomitantly.
- The hands tremor ceased when the electrodes were placed over the C3/C4 positions (where the motor control projection of the hands is located on Penfield's homunculus) and the training was designed to enhance S14 (SMR 14) or SMR, 12-15 Hz (while Theta and HiBeta were discouraged).
- The sessions done on ROSHI I, were monitored and recorded on Neurocybernetics

Case 3 – EEG recordings on NC, pre NF and post 32 ROSHI sessions



Case 4

- Case 4 – A 20 y/o student with RSD left foot
- Symptoms: chronic pain of left foot migrating to the right, headaches, and cognitive dysfunctions due to meds.
- Etiology: A heavy metal object fell on her left foot, 2 years prior to investigating BF.
- Other therapies: Physical therapy, Acupuncture
- Medications: Various antidepressants, Vicodin, Motrin

Case 4 - Training/ Results

- NF training: 20 sessions. Protocols mostly over the central sensory area at the Cz or Cz/C4 positions using the Neurocybernetics (11) followed by the ROSHI (9) NF instruments.
- NF results: Pain reduced from 8 (0-10 VAS) to 2-1. Able to return to school

Case 5

- Case 5 –63 y/o retired engineer with Idiopathic neuropathy; hypertension as co-morbidity
- Symptoms: legs pain, level 9 (0-10 VAS) anxiety, sleep disorder, hypertension
- Other Therapies: Physical Therapy
- Medications: Neurontin, Norvasc

Case 5 - Training/ Results

- NF training: 22 sessions. Protocols on NC Cz SMR (2), and on ROSHI (20) with light and electromag stimulation F3/F4 alpha inhibit.
- Results: Pain reduction down to none, anxiety controlled, better sleep, reduced Neurontin

Case 6

- Case 6 –62 y/o writer, with Neuropathy post laminectomy
- Symptoms: chronic pain low back and legs, level 8 (0-10 VAS); depression, attempted suicide, addiction to pain meds
- Etiology: laminectomy for chronic low back pain 8 yrs prior to NF
- Other Therapies: surgery, psychotherapy, Palade exercises, Yoga
- Medications: Neurontin, Wellbutrin, Vicodin

Case 6 - Training/ Results

- NF training: 46 sessions. Protocols on NC (4), Cz SMR and on ROSHI (42), F3/F4 the protocols varied from AO[I] or alpha only inhibit (8), to S14 reward (4), B16 reward (16), B17 (5) and Sync enhance (9). The Complex Adaptive Modality of light stimulation was always used with ROSHI I.
- NF Results: pain reduction down to none, no more depression, reduced meds, no more Vicodin
- After 7 years since the NF training ended, the learned skills continued to benefit the client, enhanced his performance.

Case 7

- Case 7 - A 35 y/o student with MFPS, chronic headaches (multiple origins) and (PTSD), Bruxism
- Symptoms: Headaches due to dental problems or sinus infections or allergies, left TMJ, teeth grinding , depression, anxiety, anger, sleep disorders.
- Other therapies: chiropractic, massage therapy, sinus surgeries, psychotherapy
- Medications: Neurontin, Depakote, Vicodin, Acetaminophen, Motrin, Relafen, Diazepam, Lorcet, Relafen, Baclofen, Tegretol, Serozone, Lidocaine Infusions, Antihistamines (Zyrtec, NavCon-A, Albuterol, as needed)

Case 7 - Training/ Results

- NF training: 15 sessions. Protocols used as needed at Cz or C4 SMR and C3 Beta (some sessions done with alternation of C3 beta followed by C4 SMR) using Neurocybernetics Instrument.
- NF results: Headache and TMJ pain reduced from 8-9 to 2-1, and emotional correction of depression. Anxiety from 8 to 2 - 0. Improved cognitive functioning with the reduction of the meds. Three months post the 15th session the normalization of the brain wave activity sustained and she was able to resume school.

Longitudinal case studies

- Case 8
- Case 9
- Case 10

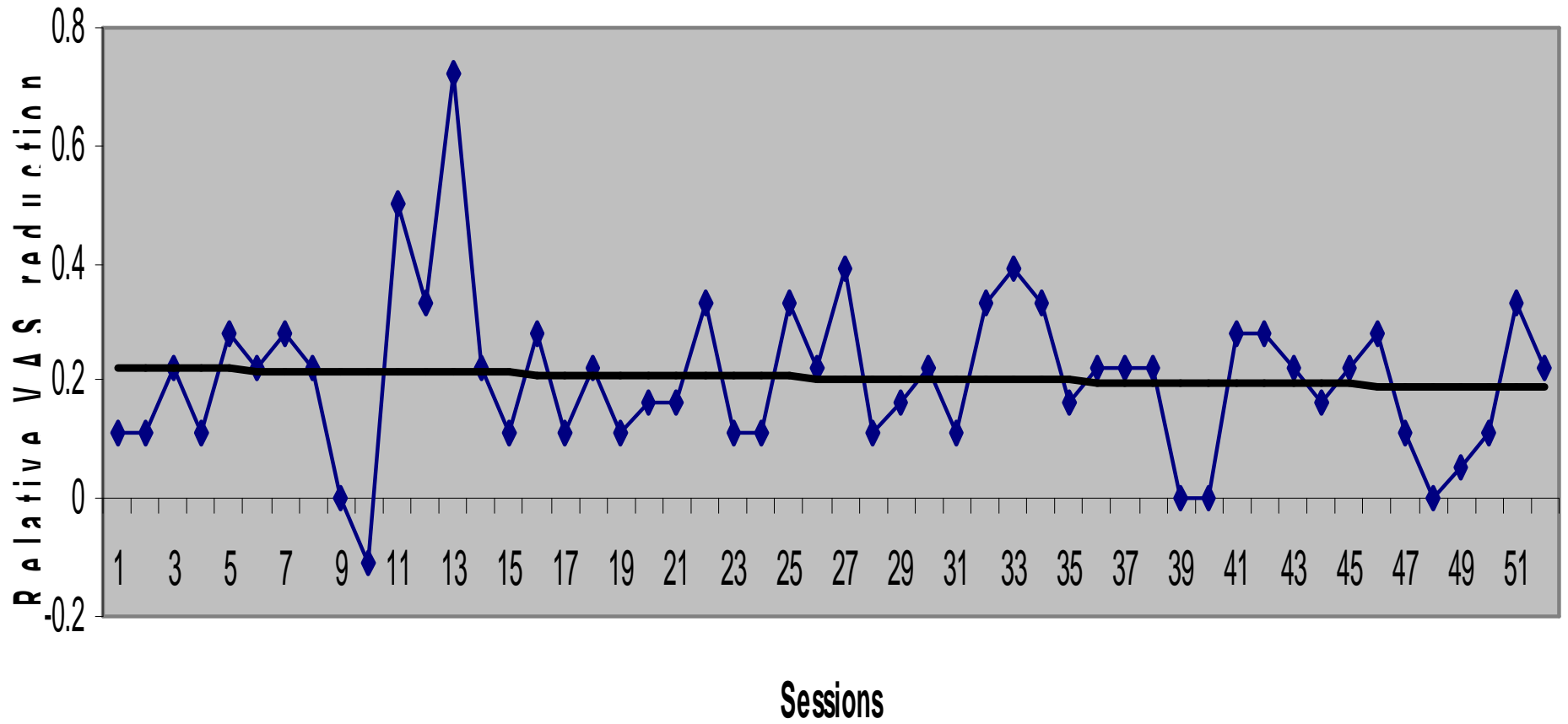
Case 8

- Case 8 - A 51 y/o teacher with chronic neck/shoulder or N/S pain, and TMJ /RSD; co-morbidity, Rheumatoid Arthritis
- Symptoms: Severe chronic pain (left neck/shoulder, TMJ, ear), numbness of left hand; sleep disorders: insomnia, teeth grinding; fatigue, nervousness
- Etiology: MVA 4 year prior to investigating BF
- Medications: Relafen, Plaquenil, Prozac, Serozone (Elavil, Zoloft, Sinequal in the past) HRT for menopause.

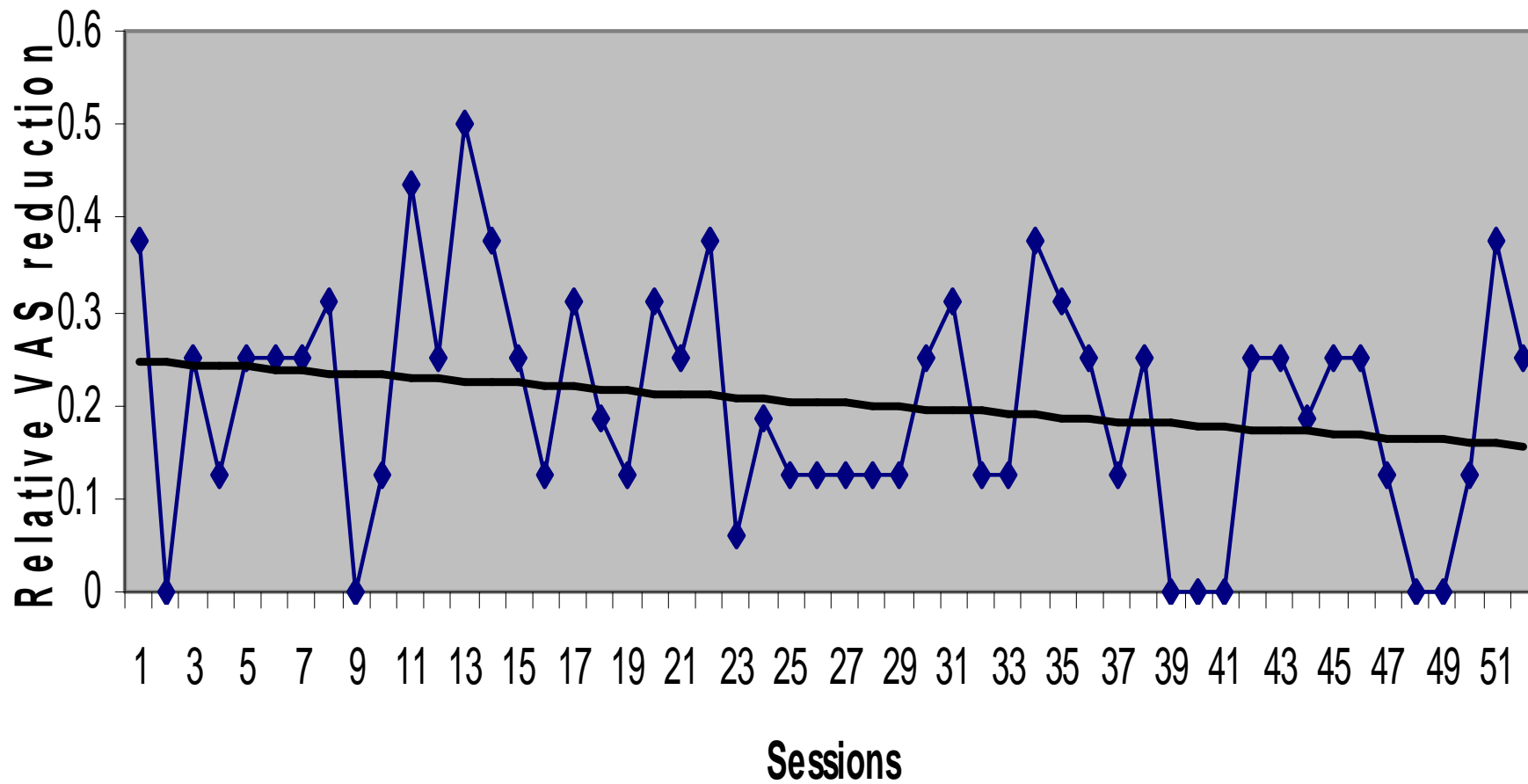
Case 8 - Training/ Results

- NF training: 22 sessions on NC, resumed NF after a 5 months brake; then continued to session 51 on NC, followed by 3 re-evaluations
- NF training at Cz or C4 - SMR enhanced, and theta and high beta discouraged.
- NF Results: TMJ and neck/ shoulder pain level lowered from 8-9 to 2-4 and gradually was reduced and kept for longer time, even after the NF ended, at acceptable levels of 1-3 on the Visual Analog Scale, or VAS, as reported and presented in Figures 5-9.

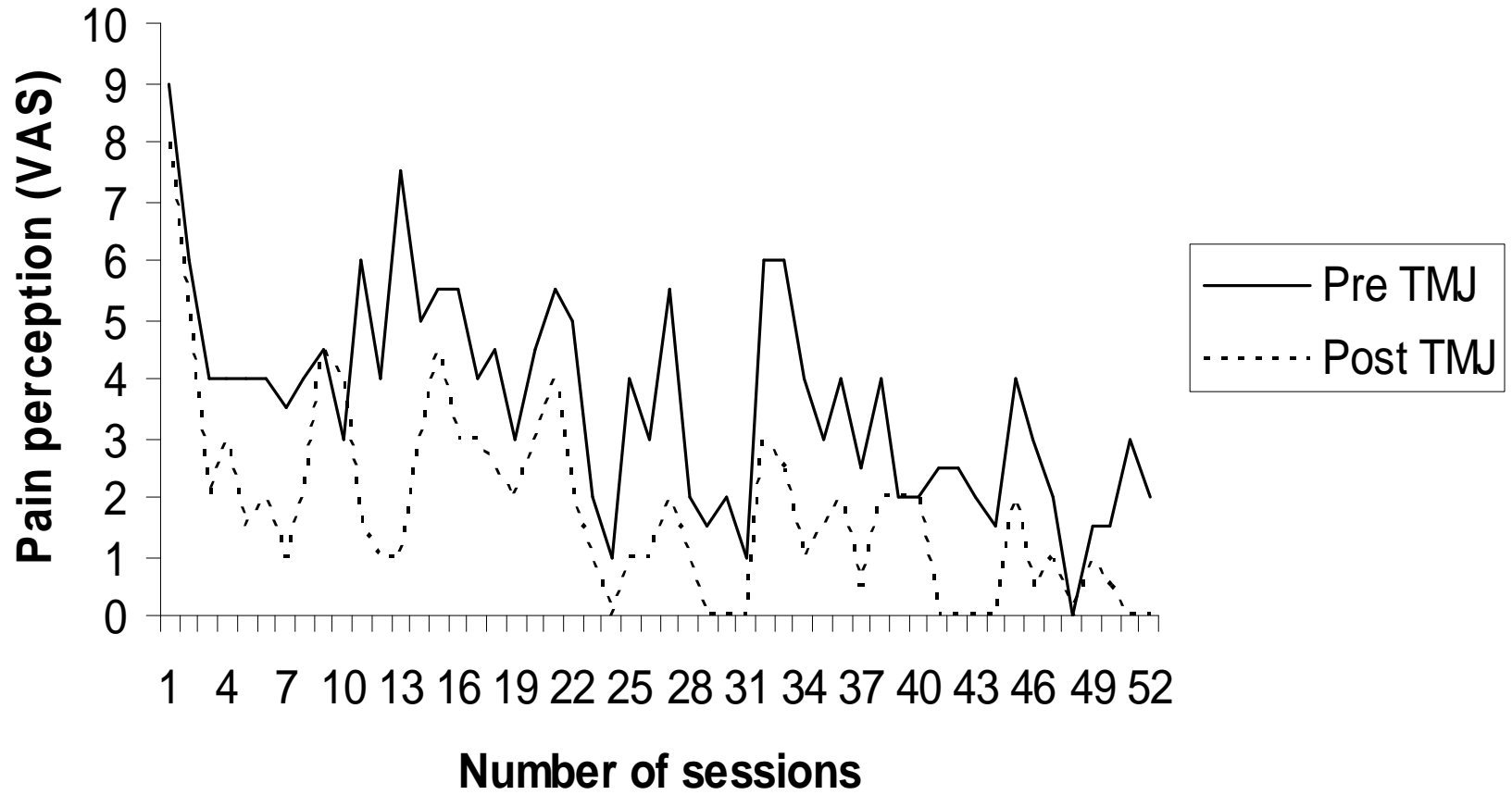
Case 8 - Temporo Mandibular Joint pain



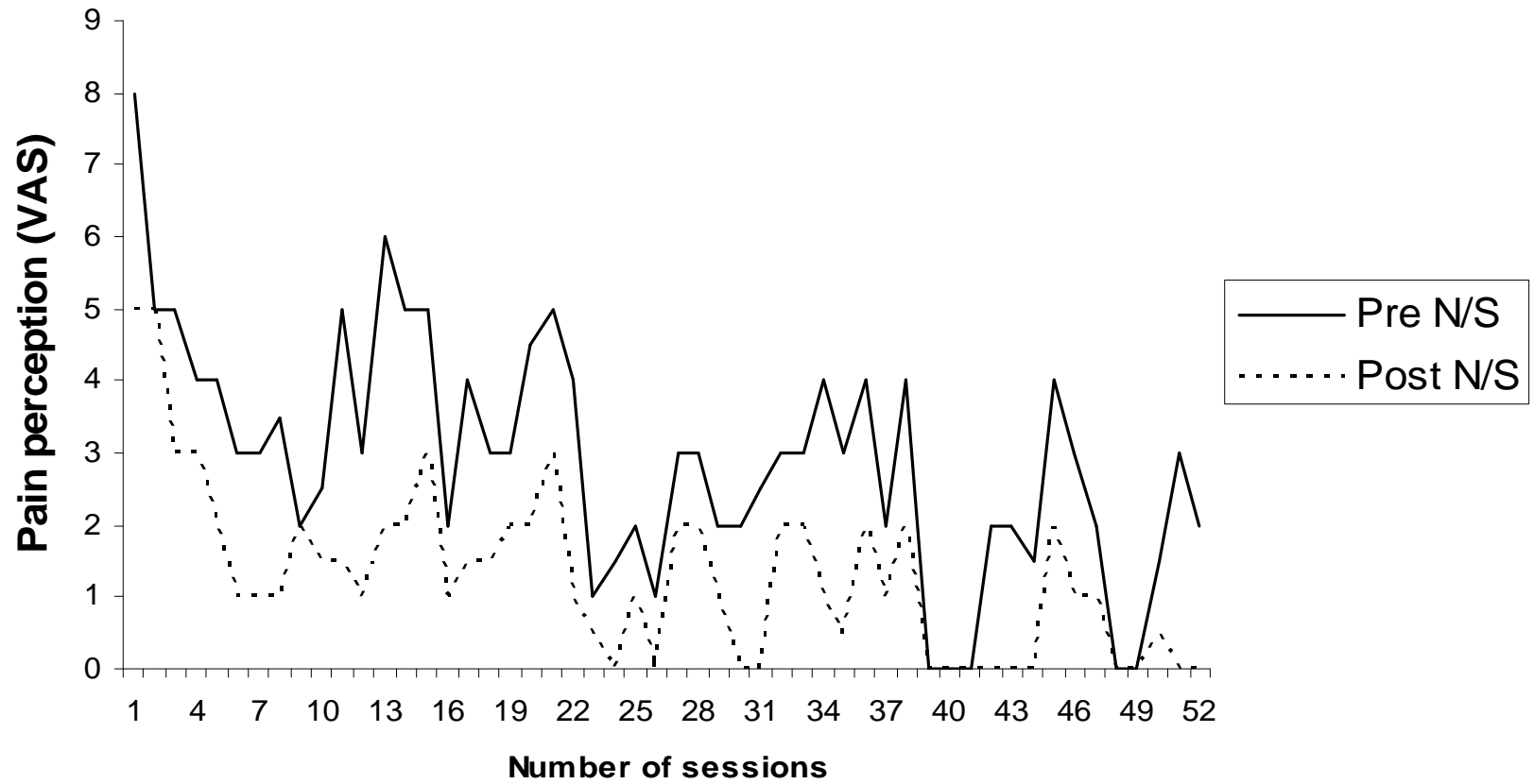
Case 8 - Neck/Shoulder pain



Case 8 - NF Treatment Effectiveness in TMJ pain control



Case 8 - NF Treatment Effectiveness in N/S pain control



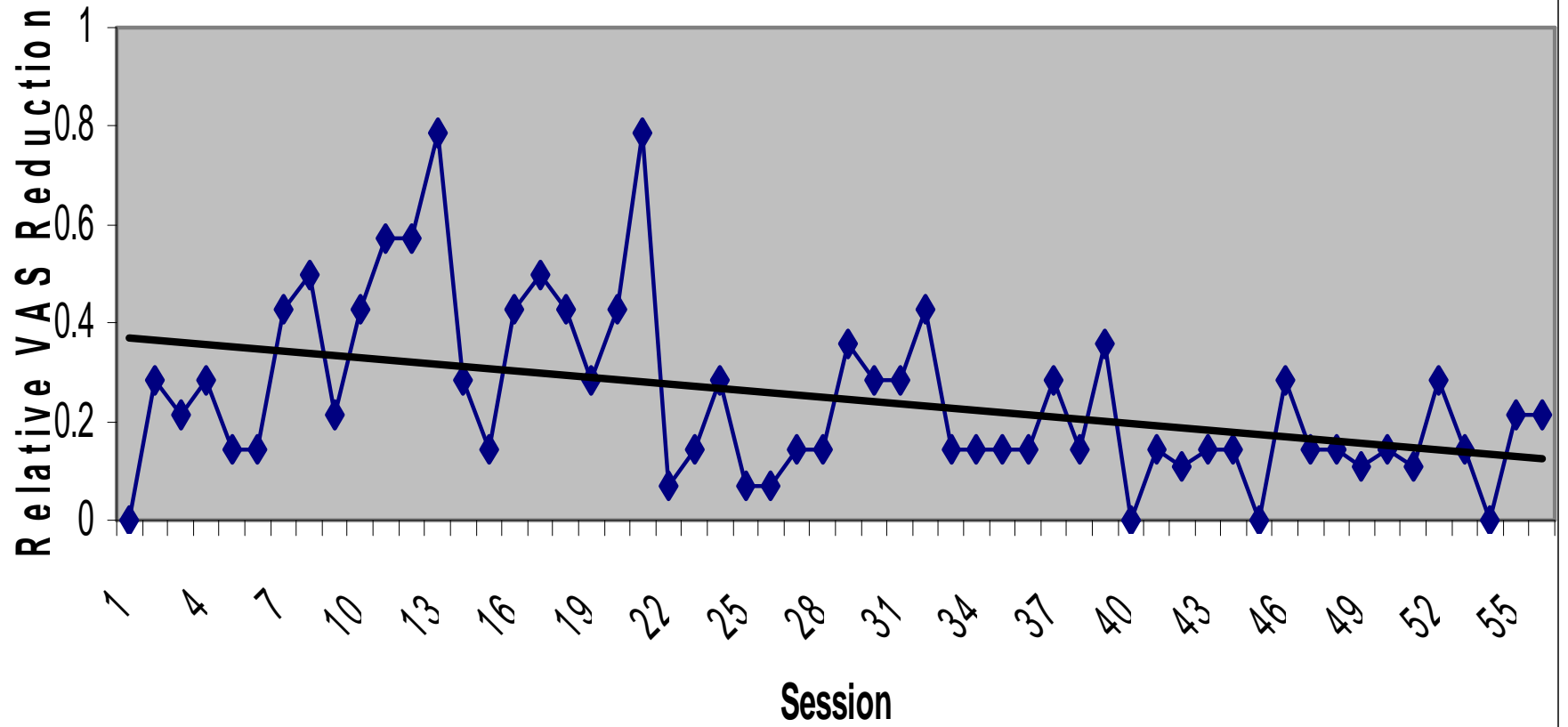
Case 9

- Case 9 - 60 y/o (♀) Housewife with Chronic pain; co-morbidities: Parkinson's Disease (PD), Skin and Colon cancer, Chronic Lymphatic Leukemia (CLL)
- Etiology: 2 years prior BF fell and injured left knee, diagnosed also with CLL and PD.
Symptoms: Severe Lower back and left knee pain, level 8-9 (0-10 VAS), spasticity of left foot, numbness of the left hand, tremor, depression, Anxiety, sleep disorder, tinnitus.
- Medications: Cinemet, Trazadone, Zoloft, Lodosyn, HRT, Oscal and multivitamins.

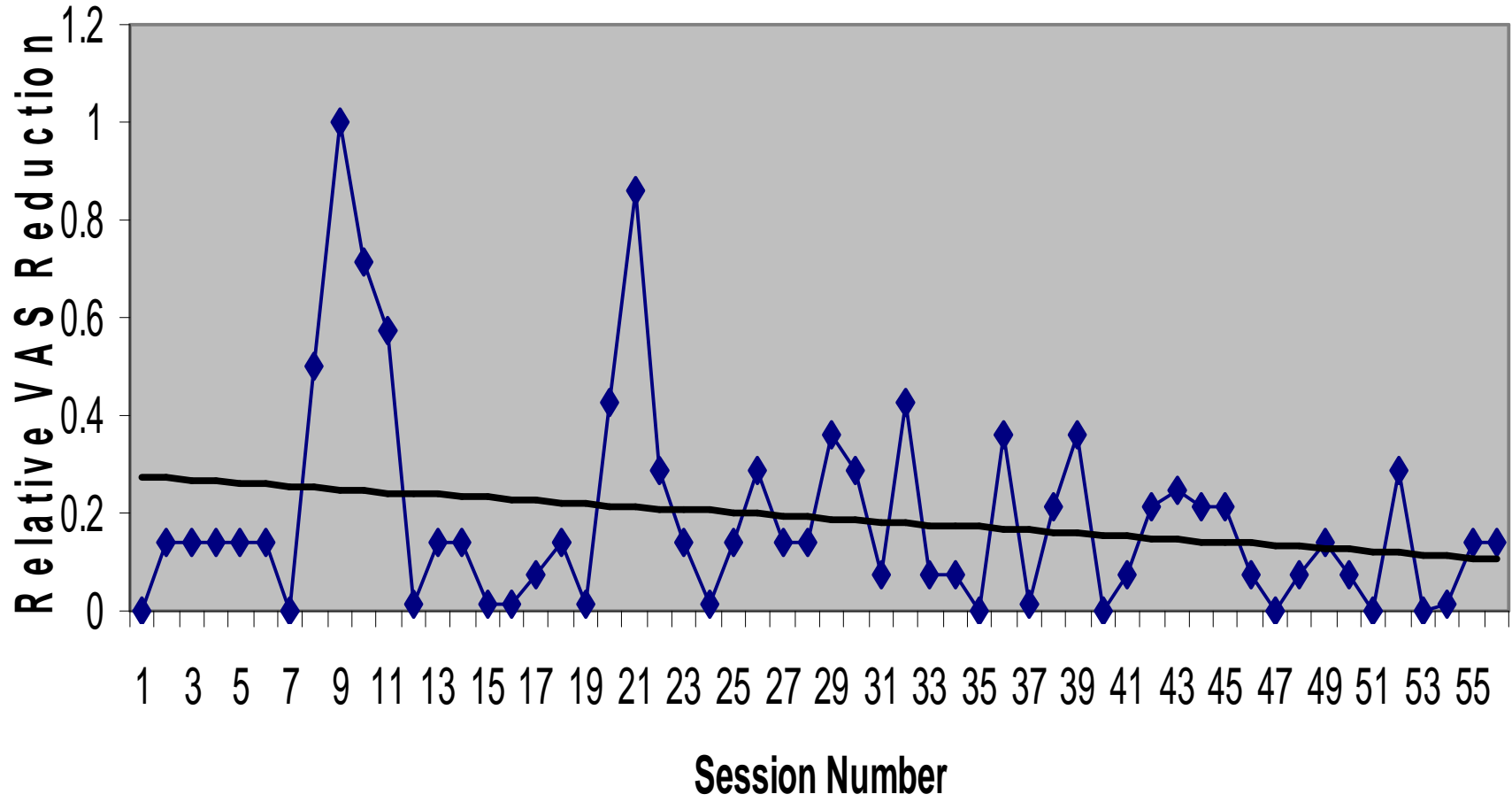
Case 9 - Training/ Results

- NF training: 56 sessions on NC, mostly at Cz enhance SMR and reduce high beta.
- Results: Spasticity lowered from 8-10 to 3 post 20 sessions and reduced to none after 50 sessions; Tremor more controlled and better after each session, imperceptible after 50 sessions;
- Pain reduction to 2-1, anxiety/ depression controlled, better sleep, reduced meds (under physician control). Pain continued to be under control even after 1 year and a half or 2 years and half after the NF training ended (see Figures 10-14)

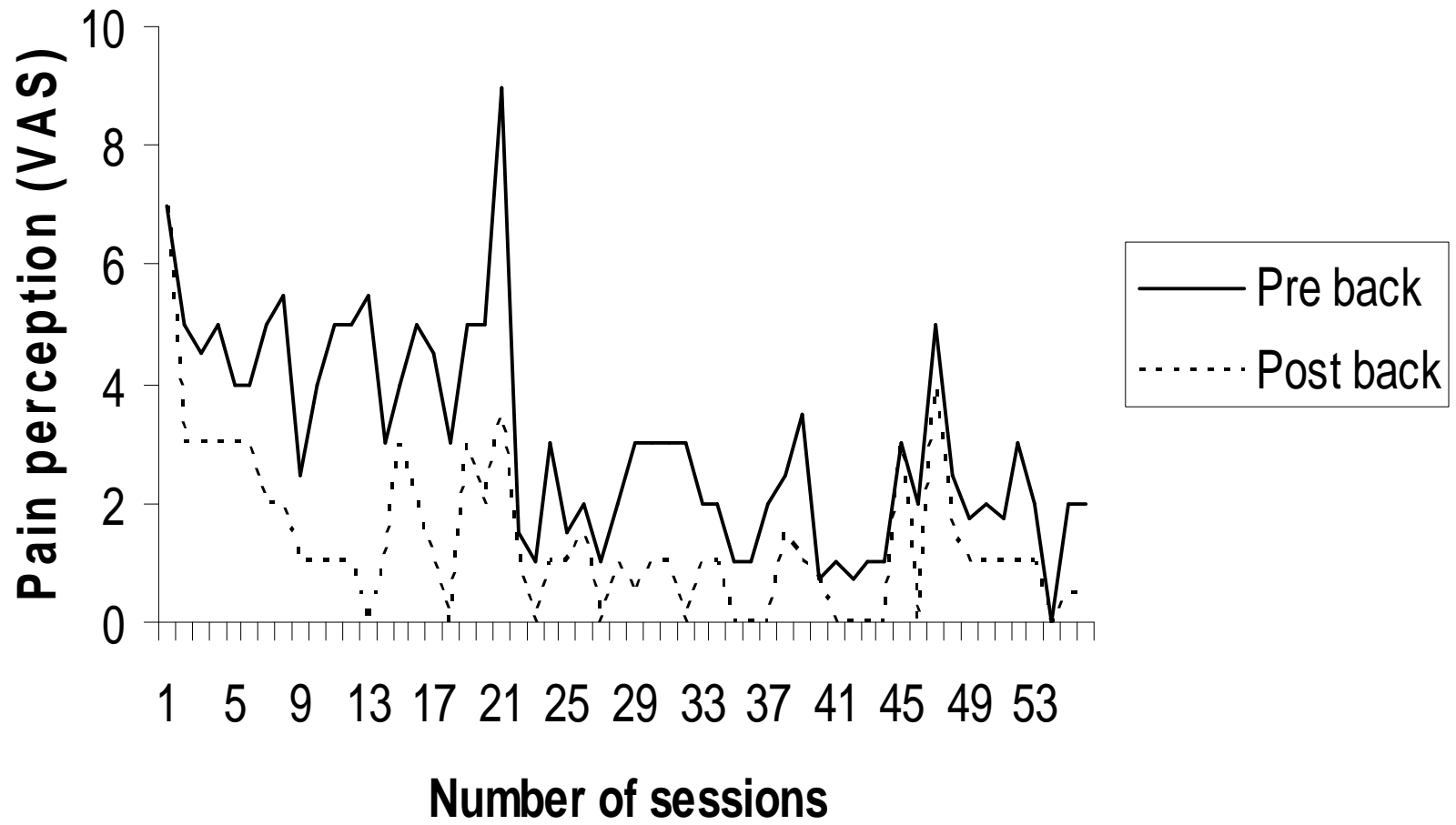
Case 9 - Back Pain



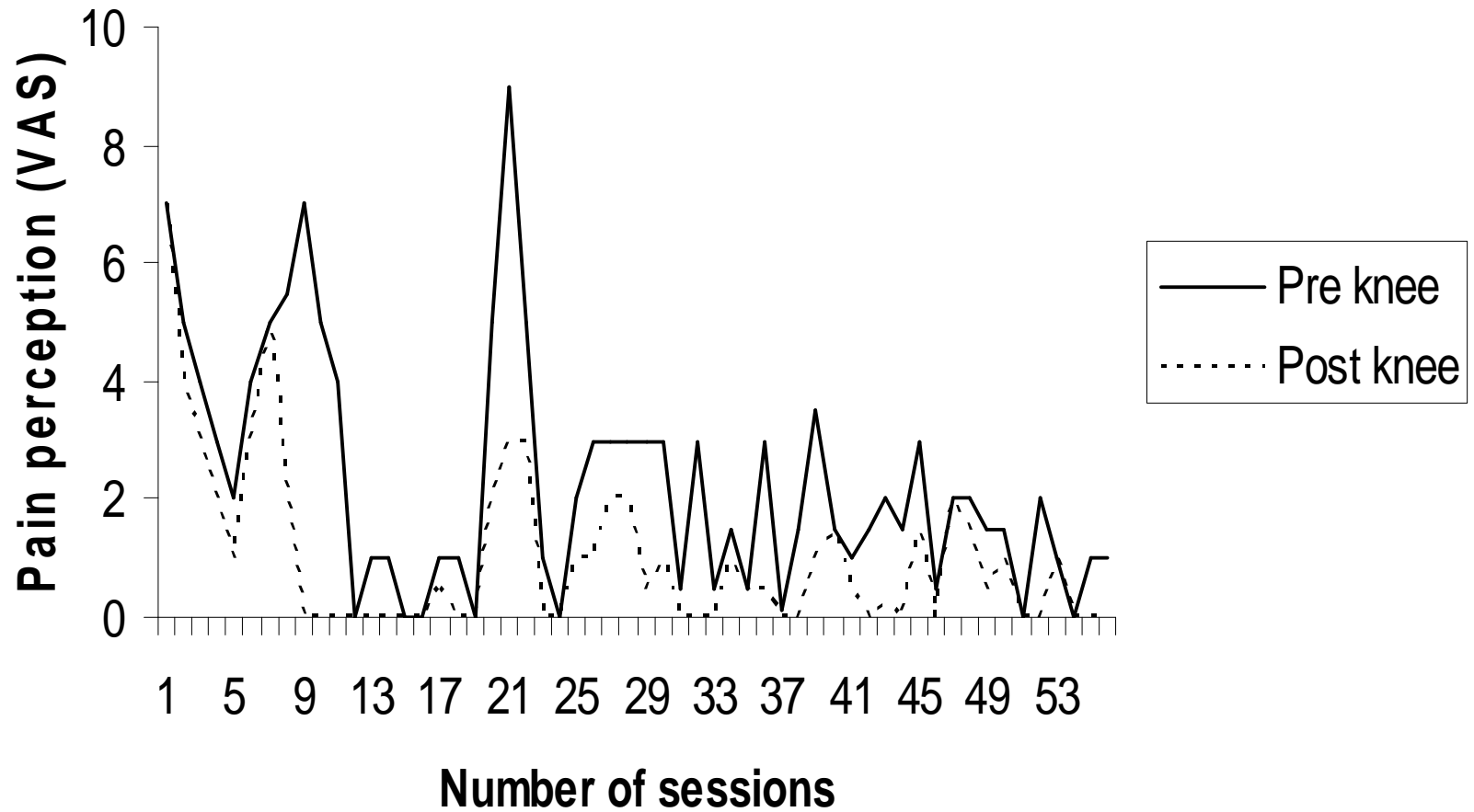
Case 9 - Knee Pain



Case 9 - NF Treatment Effectiveness in back pain control



Case 9 - NF Treatment Effectiveness in knee pain control



Case 10

- Case 10 – A 42 y/o carpenter with left inguinal pain post surgery and kidney stones (185 over the years), mTBI, chronic colitis, addictions to pain killers/ marijuana
- Symptoms: Depression/ Anger, Chronic Fatigue; Left inguinal pain, Low back pain
- Etiology: Hernia surgery and epididymectomy, 4 years prior to investigating BF; work injury (hit with a 2X4 at the posterior right of the head)

Case 10

- Other therapies: Acupuncture, chiropractic, herbs
- Medications: Vicodin, Morphin (repeated ER visits), Iboprufen 2400mg, Epinephrine
- NOTE: all the meds stopped after 15 sessions of NF!

Case 10 - Training

- 112 Neurofeedback sessions: Neurocybernetics (9): C4 SMR, C3 Beta, P3 Alpha [E]; ROSHI (103): enhanced NF by light or electromagnetic closed loop EEG: F3/F4 alpha only inhibit, AO[I]; theta only inhibit, TO[I], or theta 4, T4[I]; P3/P4 , alpha only enhanced, AO[E]; C3/C4 or Cz SMR; F3/F7, synchronization inhibit, Sync [I]; Fp1/T3 Sync [I]. When NF was completed, continued the home training with a pROSHI (personal ROSHI entrainer/ disentrainer, non-NF instrument).

Case 10 - Results

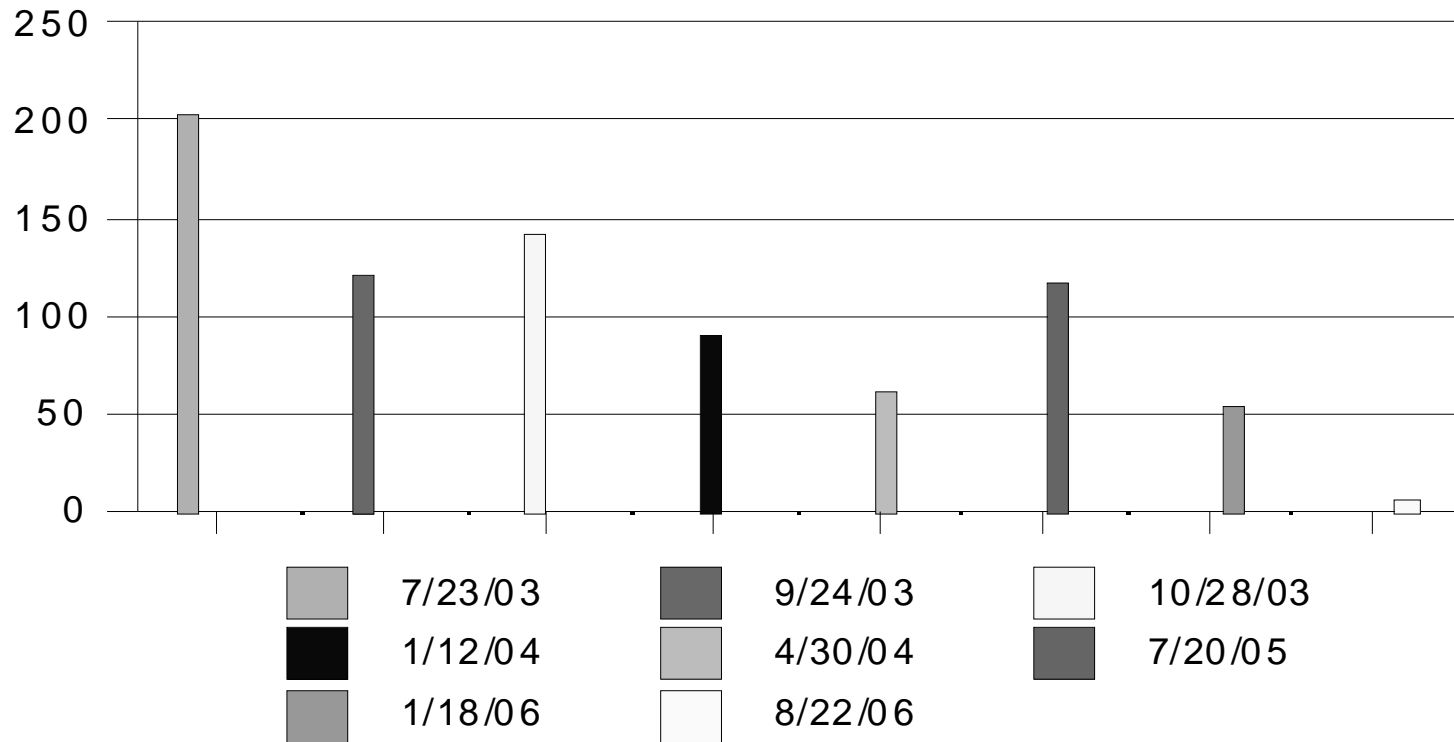
- Pain reduction from 9-10 immobilizing pain to 3-1 and complete elimination of pain killers.
- Able to go back to work and produced musical CD, due to enhanced mental performance!

Case 10

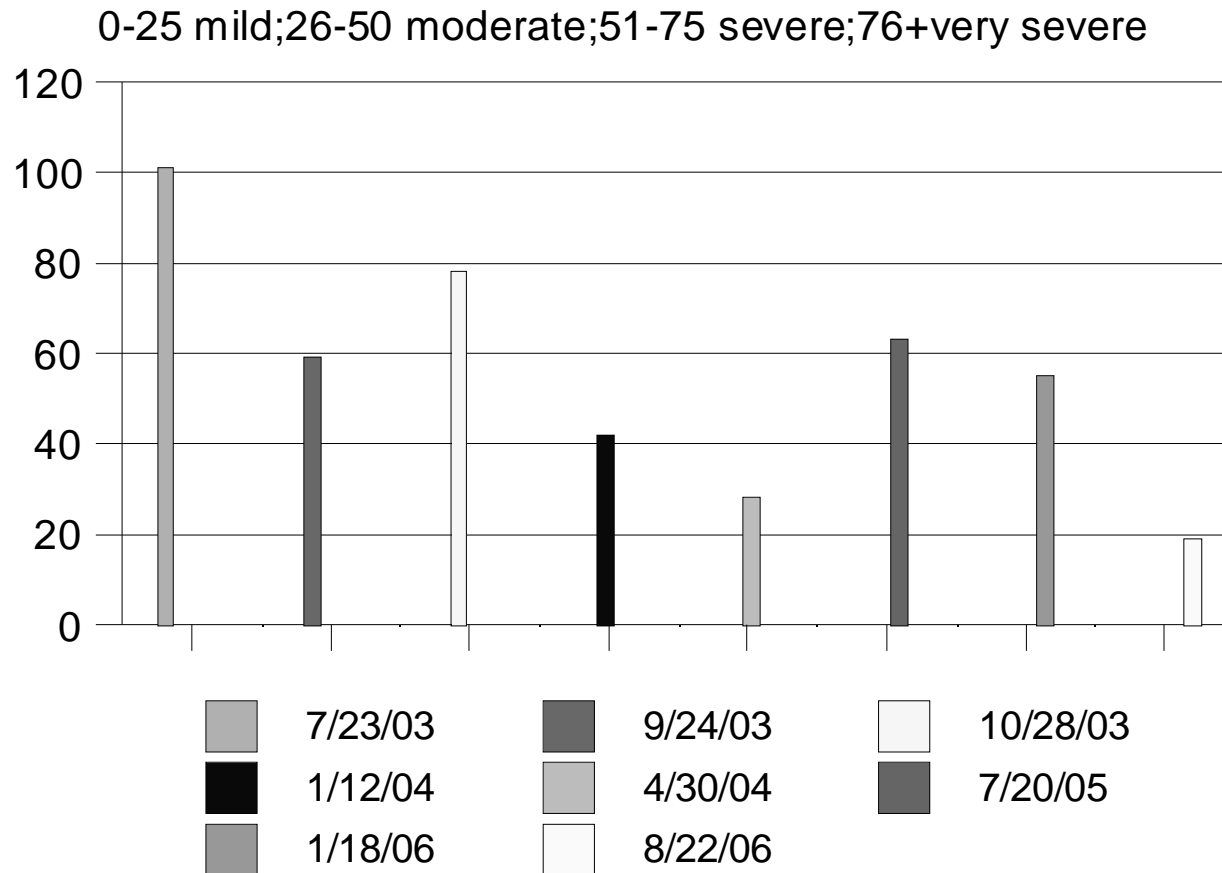
- Progress evaluation
- Subjective tests:
 - SCL-90R
 - Stress Test
 - CES-D, depression test
- Objective tests:
 - IVA
 - QEEG pre, during and post NF

Case 10 – SCL-90R

Max=360; Min=0

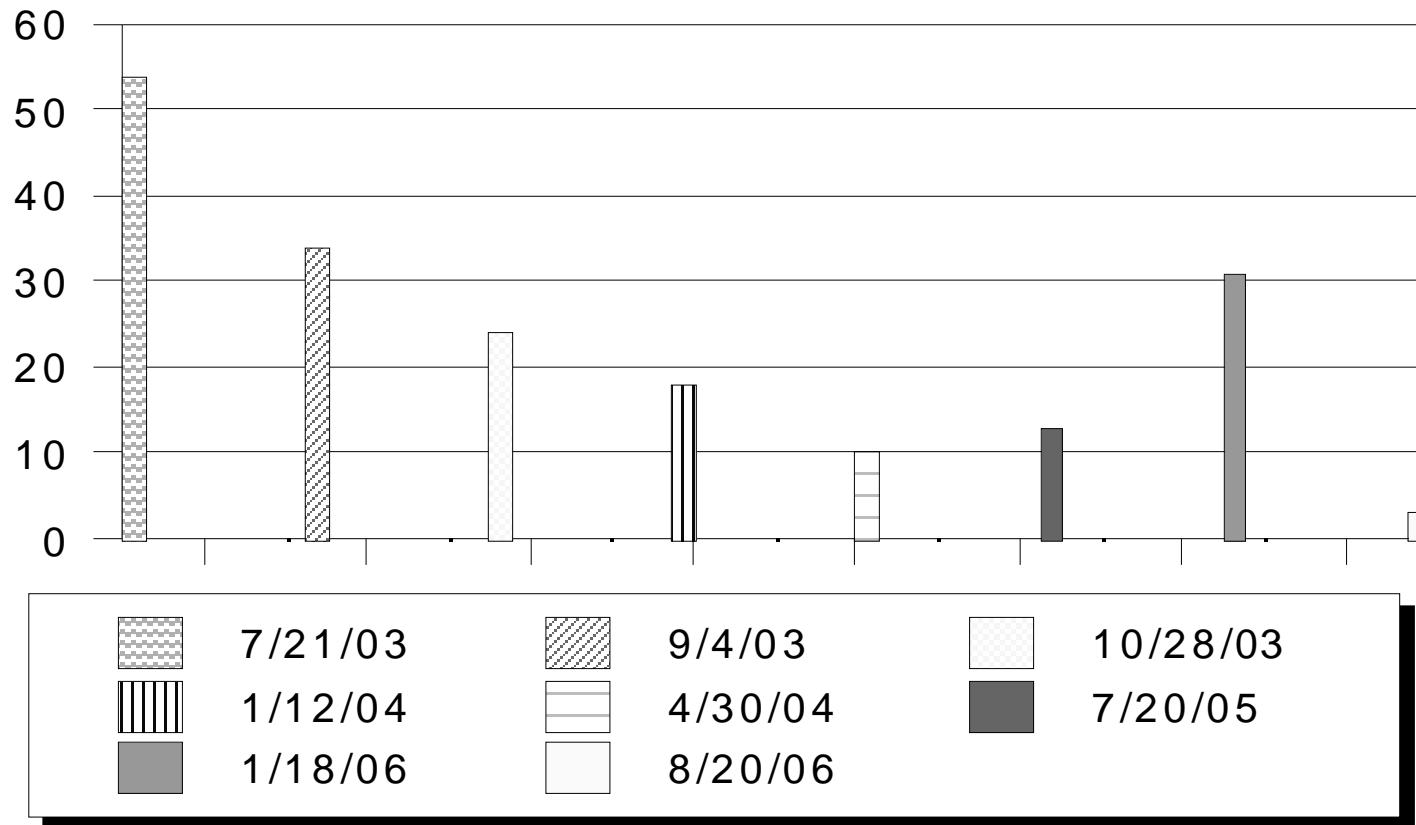


Case 10 – Stress Test

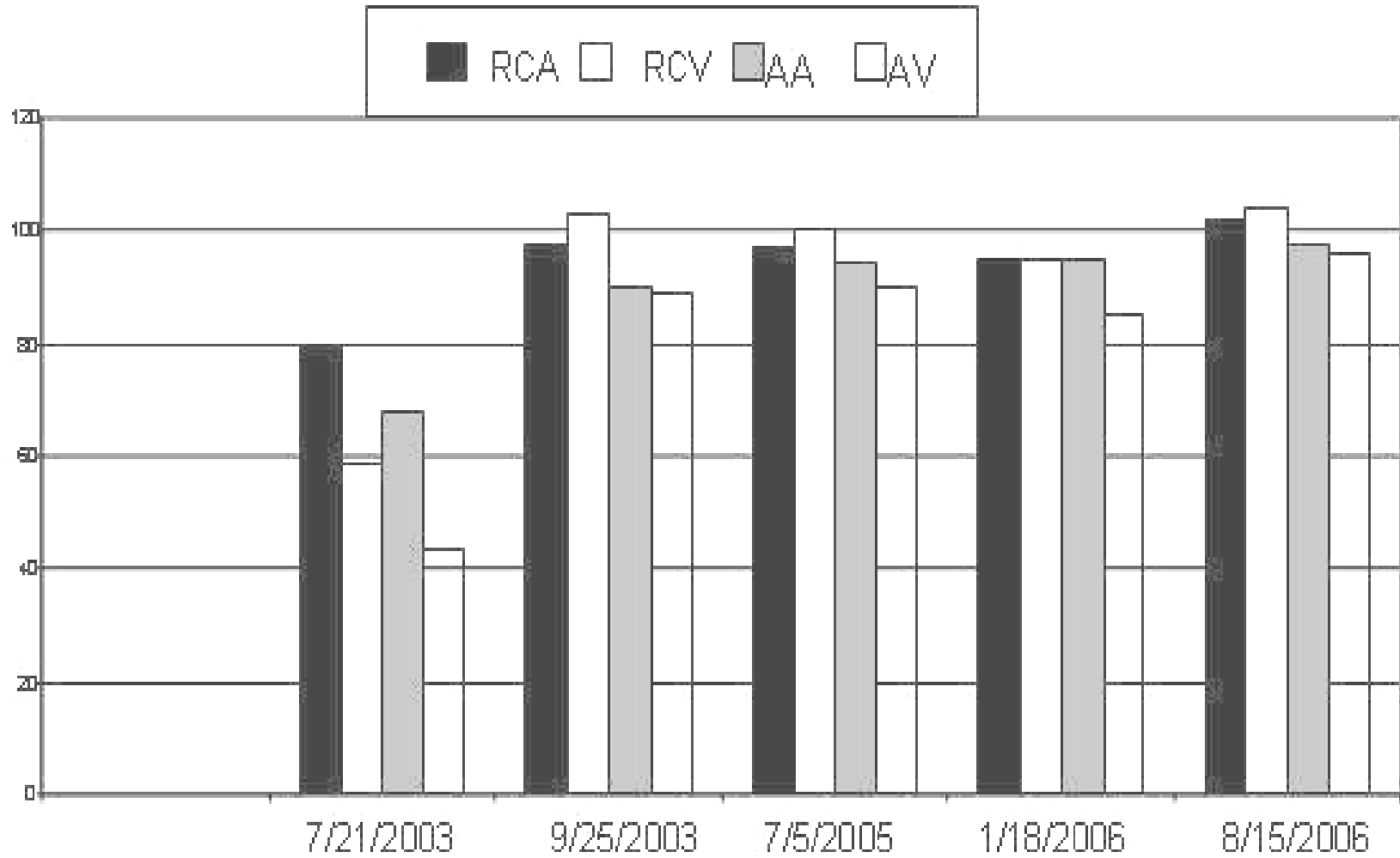


Case 10 - CES-D – Depression scale

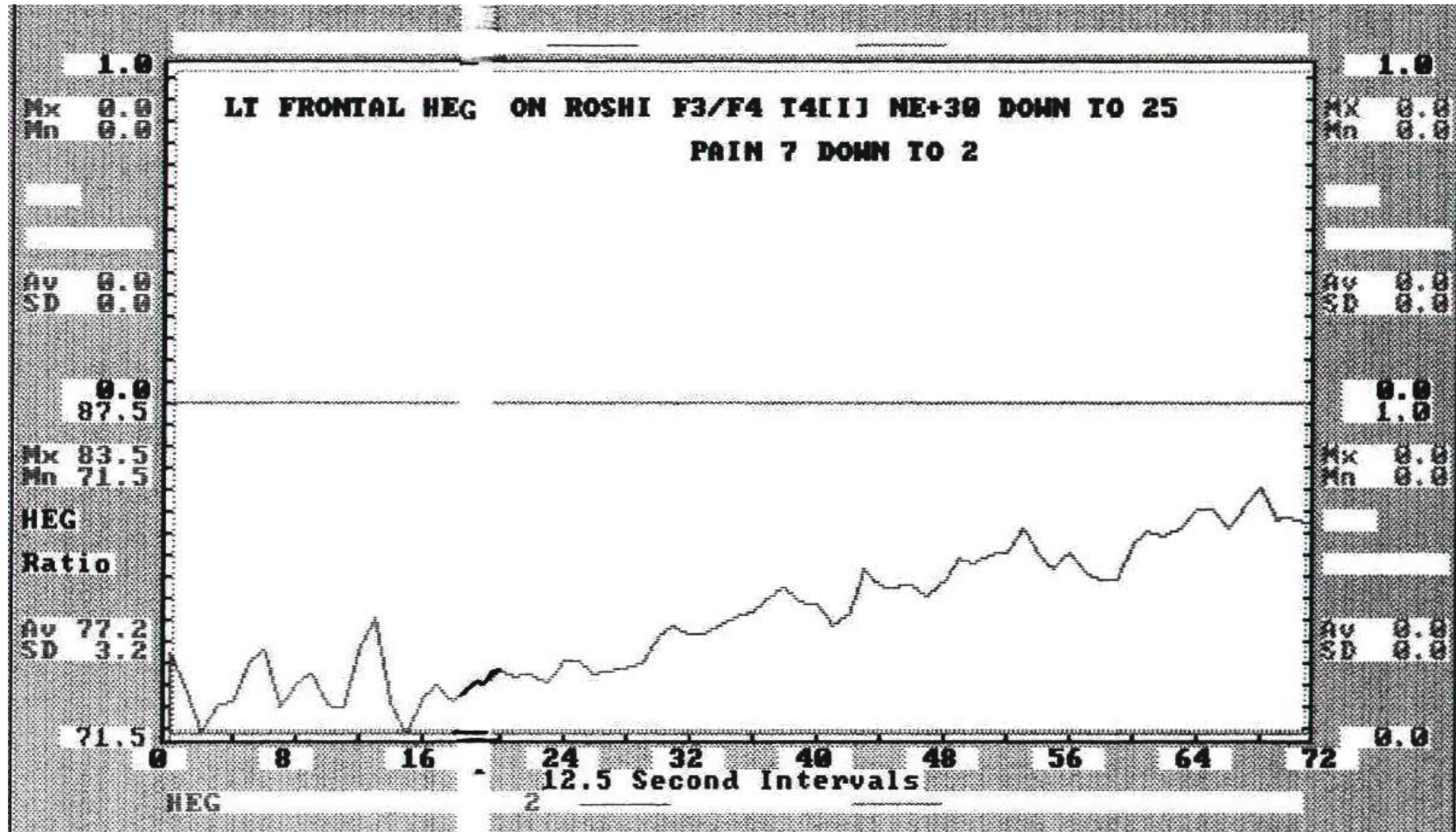
Note: CES-D max=60; over 16 + depression



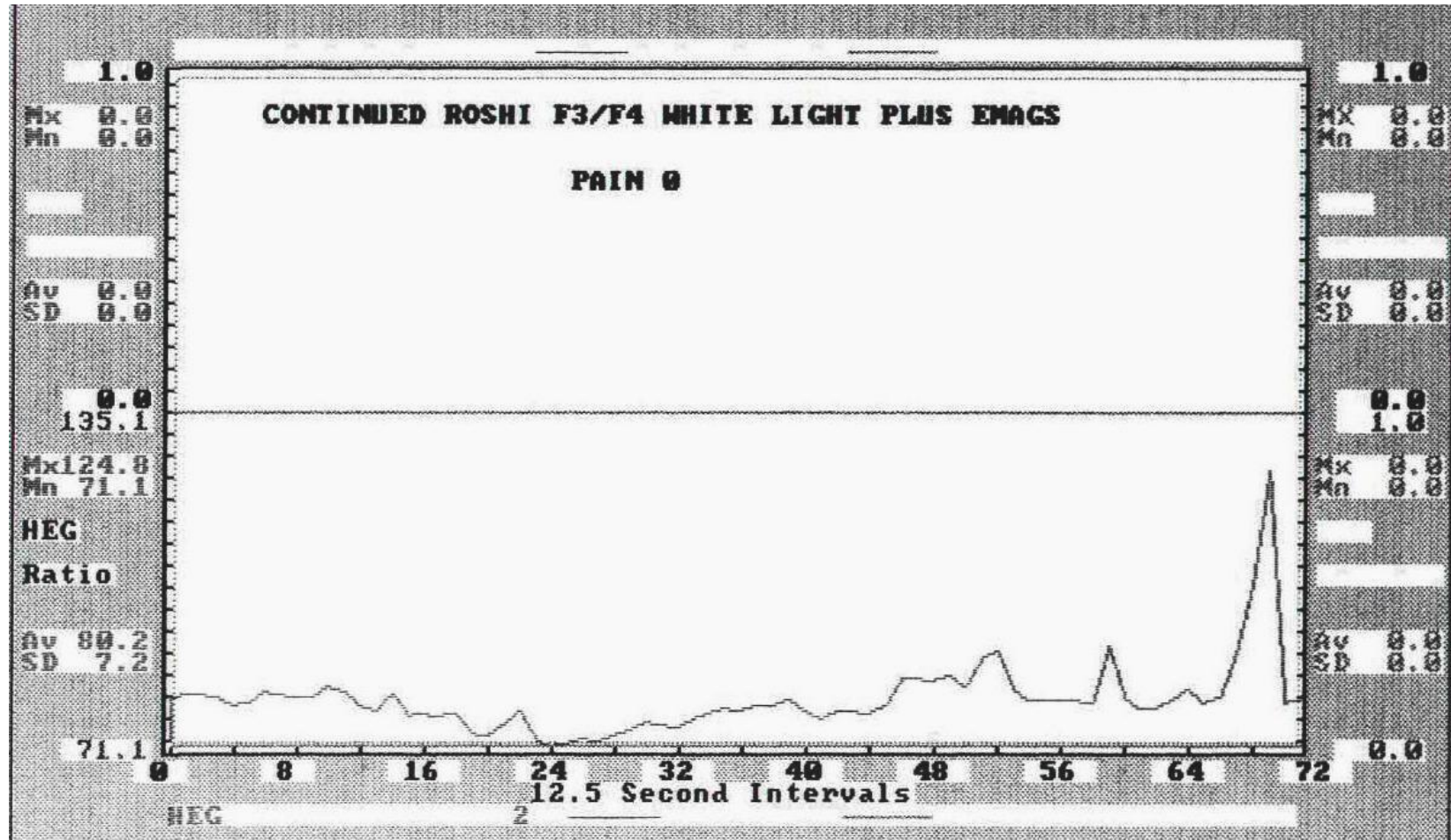
Case 10 IVA results



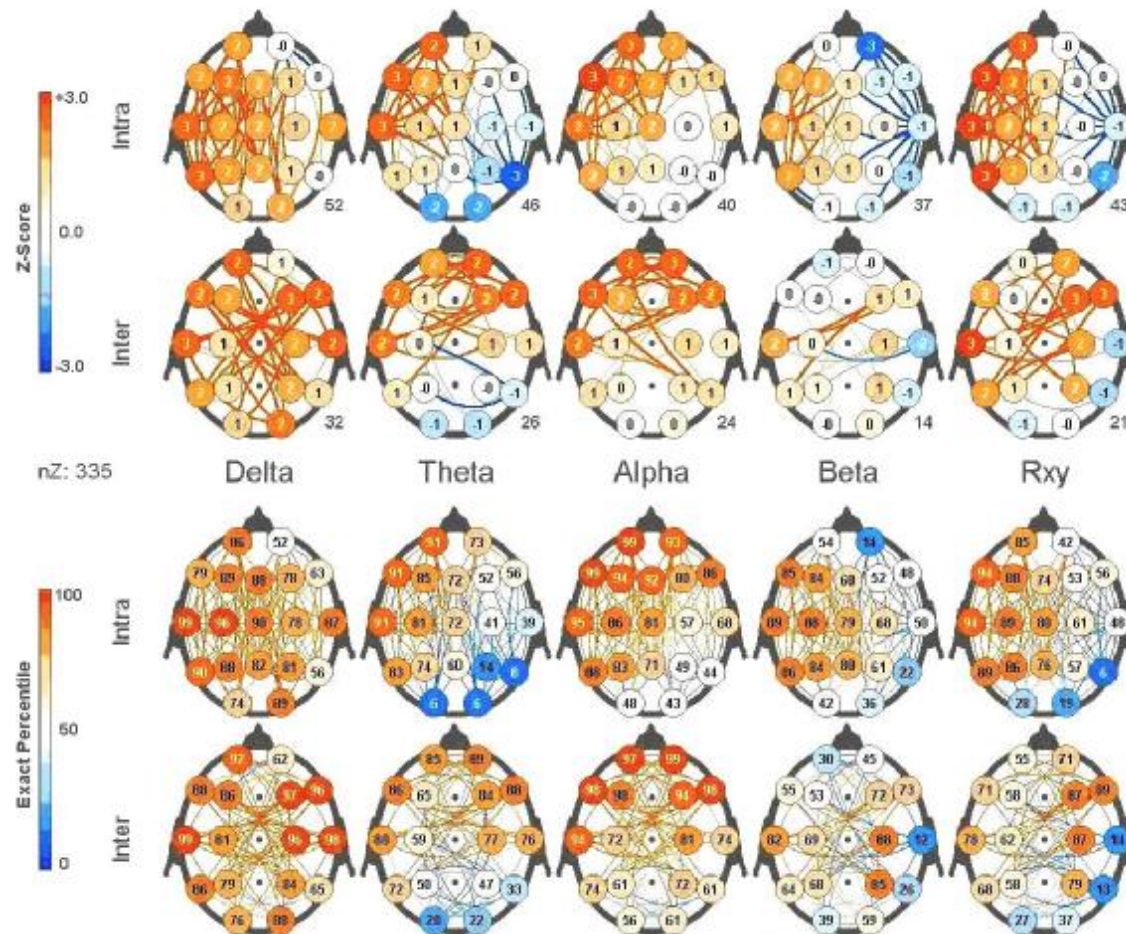
Case 10 – HEG evaluation during NF training on ROSHI



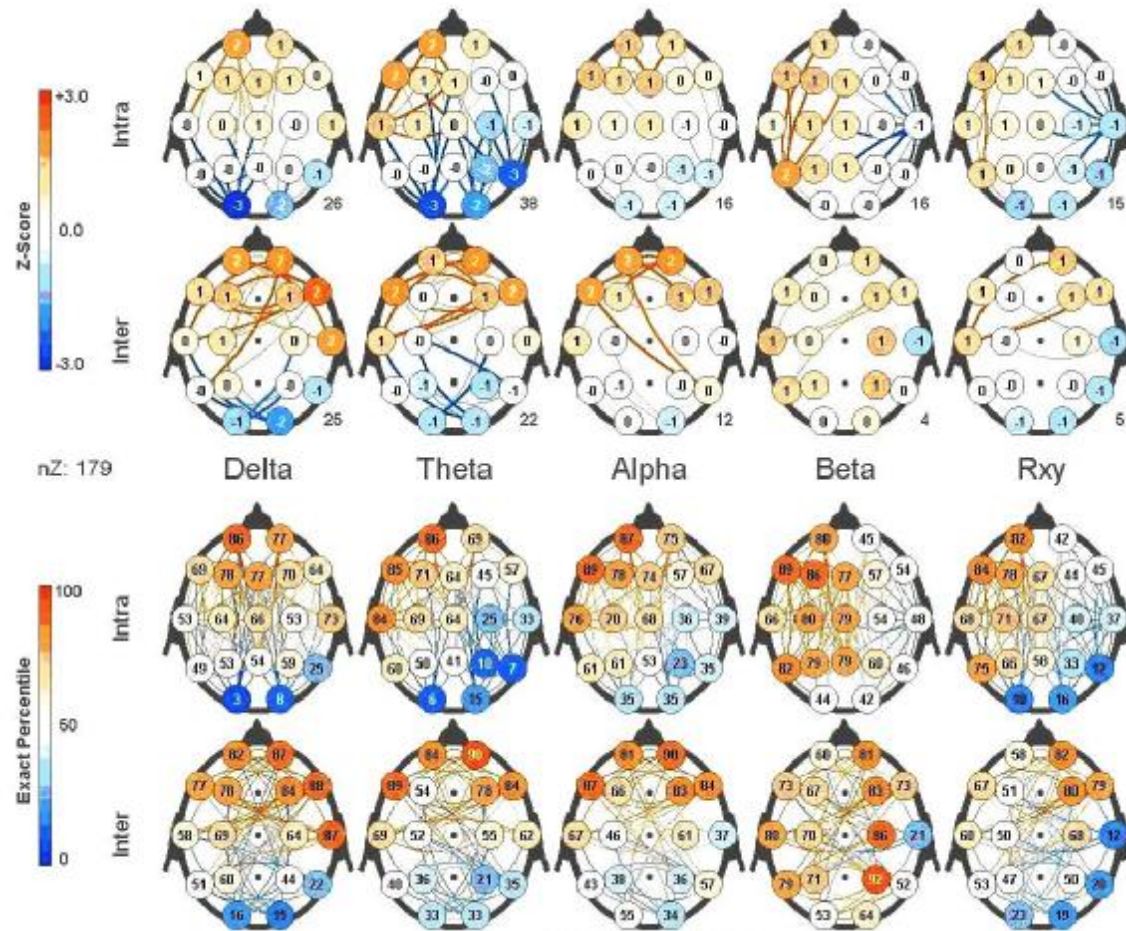
Case 10 – HEG evaluation during NF training on ROSHI (continuation)



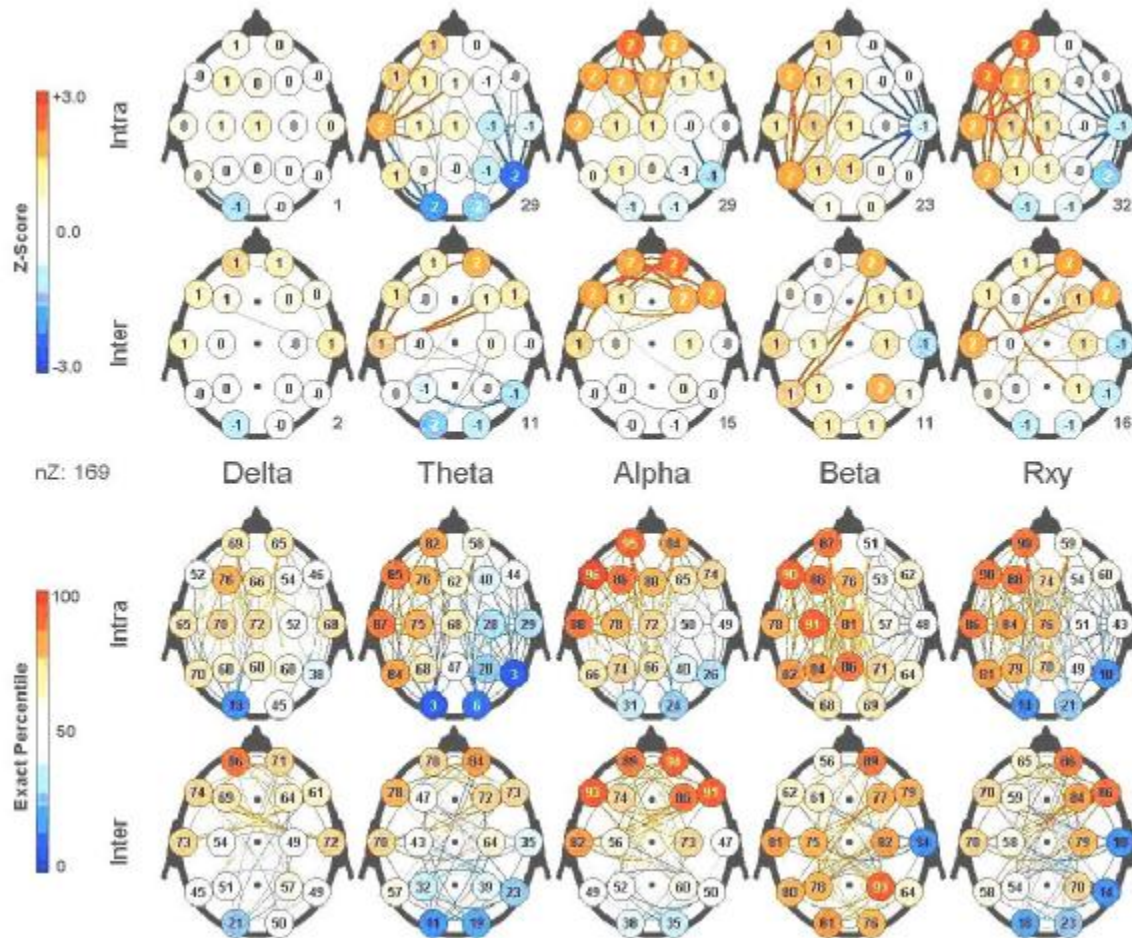
Case 10 – QEEG connectivity map pre NF (NeuroRep program)



Case 10 – QEEG connectivity map during NF (NeuroRep program)



Case 10 – QEEG connectivity map post NF (NeuroRep program)



Statistical Analysis of the NF Efficacy in pain syndromes

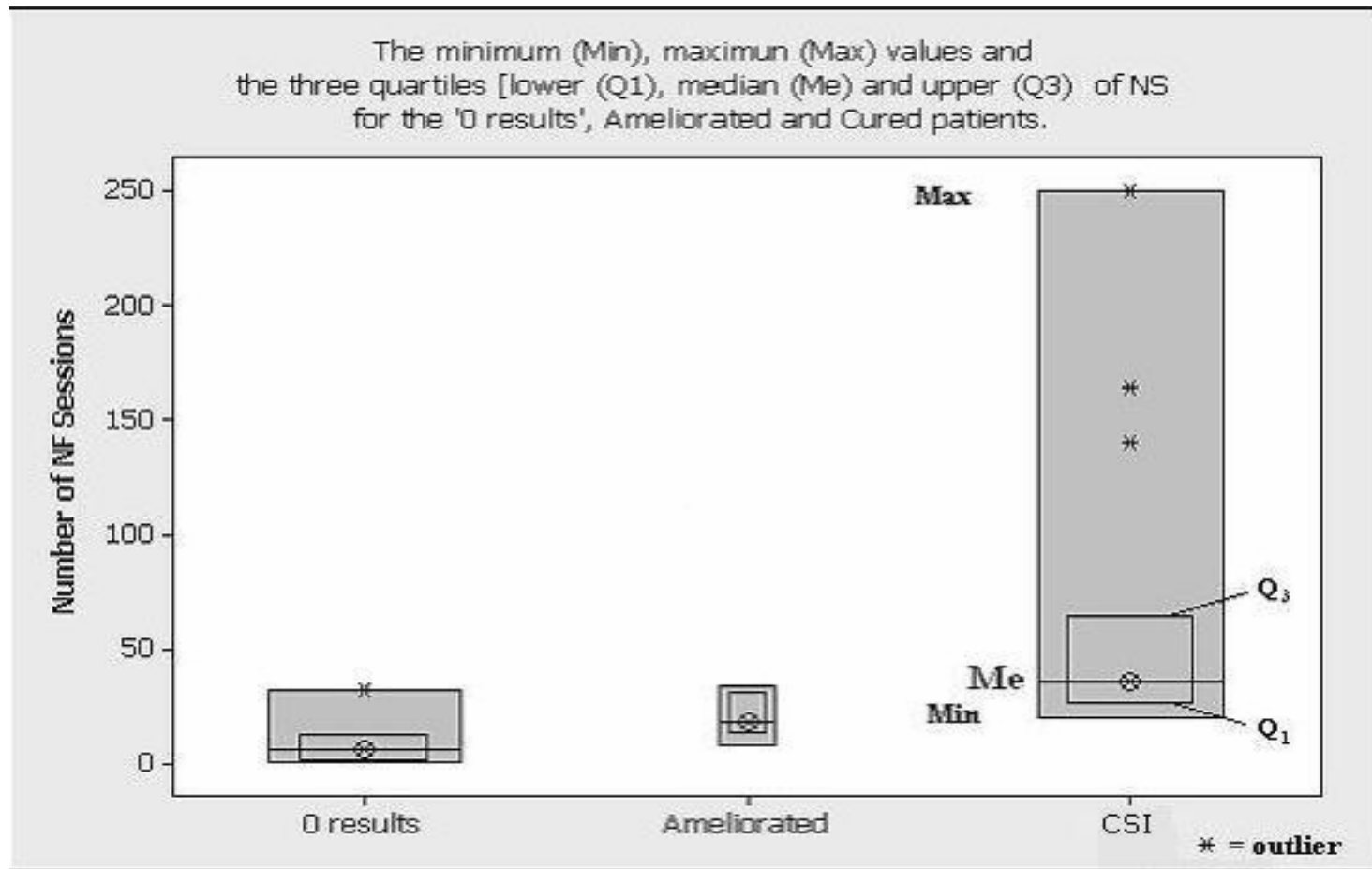
Main Pain Diagnostics and/or localizations	No. patients
Headache & Migraines (Headaches only)	Total 58 (19)
Neck & Shoulder Pain	9
Back & Leg Pain	30
MFPS & Fibromyalgia	10
CRPS type I, II	13
Abdominal pain of Different origins	7
Rheumatoid Arthritis (RA) /	3 /
Other (e.g. Cancer pain)	17

Number of NF sessions influenced the outcome!

No. of Patients	No. cases	Results
1 NF sessions after evaluation	15	0
2-10 NF sessions	33	[1 ameliorated, (A)]
11-19 NF sessions	25	(3A)
>19 NF sessions	74	[2A + 68 "CSI"* = 70]
Success rate CSI*		68 / 74 or 92%
Success rate of positive results		70 / 74 or 95%

(CSI is abbreviation for "Clinical Significant Improvement")

Number of NF training sessions on the Efficacy of the NF in Pain



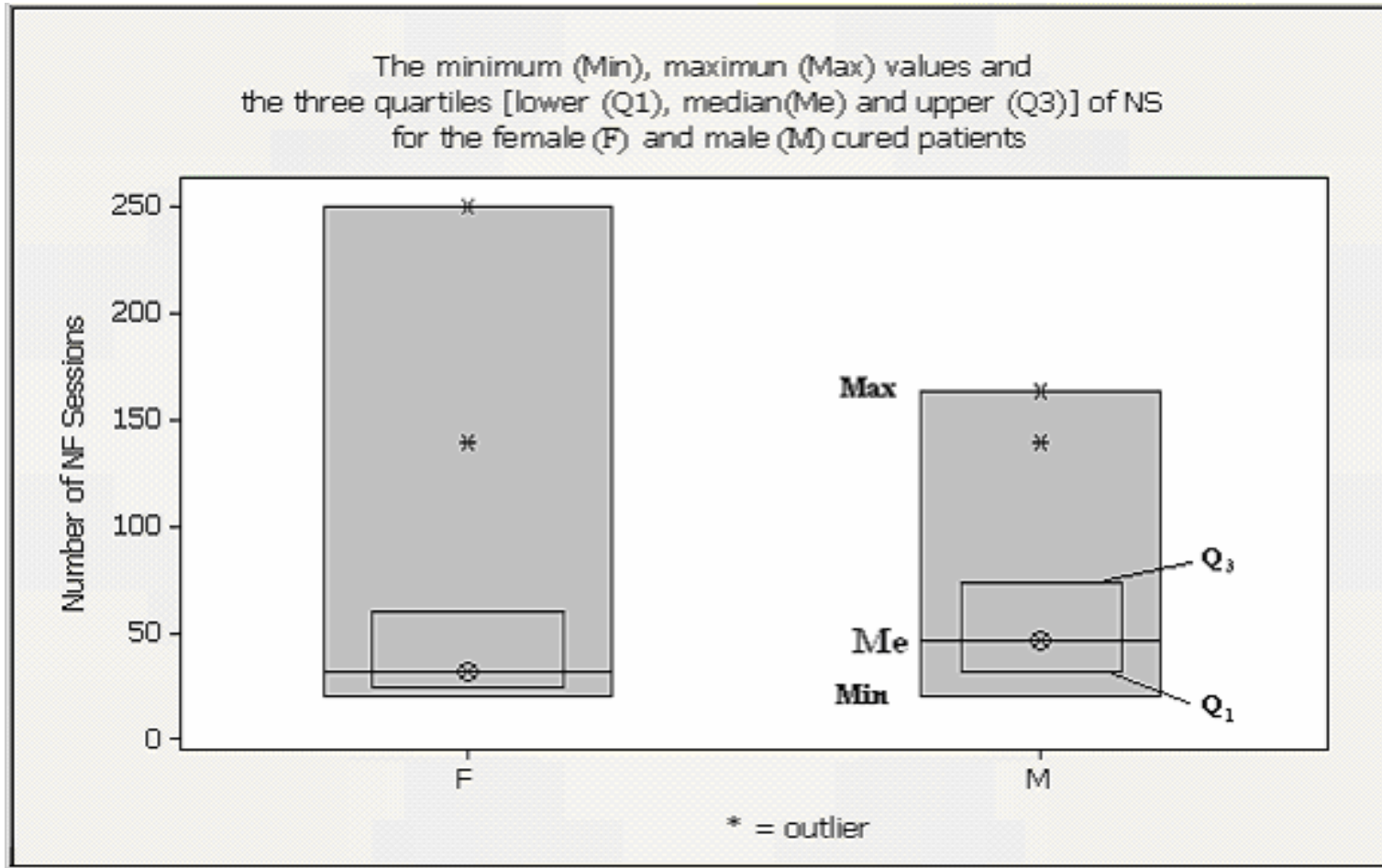
Efficacy Results	No of Patients	Min	Lower Quartile Q1 (25%)	Median Me (50%)	Upper Quartile Q3 (75%)	Max
Zero results	73	1	2	6	13	32
A	6	8	14	18.5	25	34
CSI	68	20	27	35.5	64.5	250

The differences (Kruskal-Wallis test) between medians 6.0, 18.5, 35.5 are significant ($p < 0.001$)

Case control study of the Efficacy of NF training for “more than 19 sessions”

NF exposure	Cases – with disease (Zero effect)	Controls – without disease (Positive effect)
Exposed to enough NF training (More than 19 sessions)	4	70
Not exposed to enough NF raining (1-19 NF sessions)	69	4

Sex effect on the NF Efficacy in Pain Management

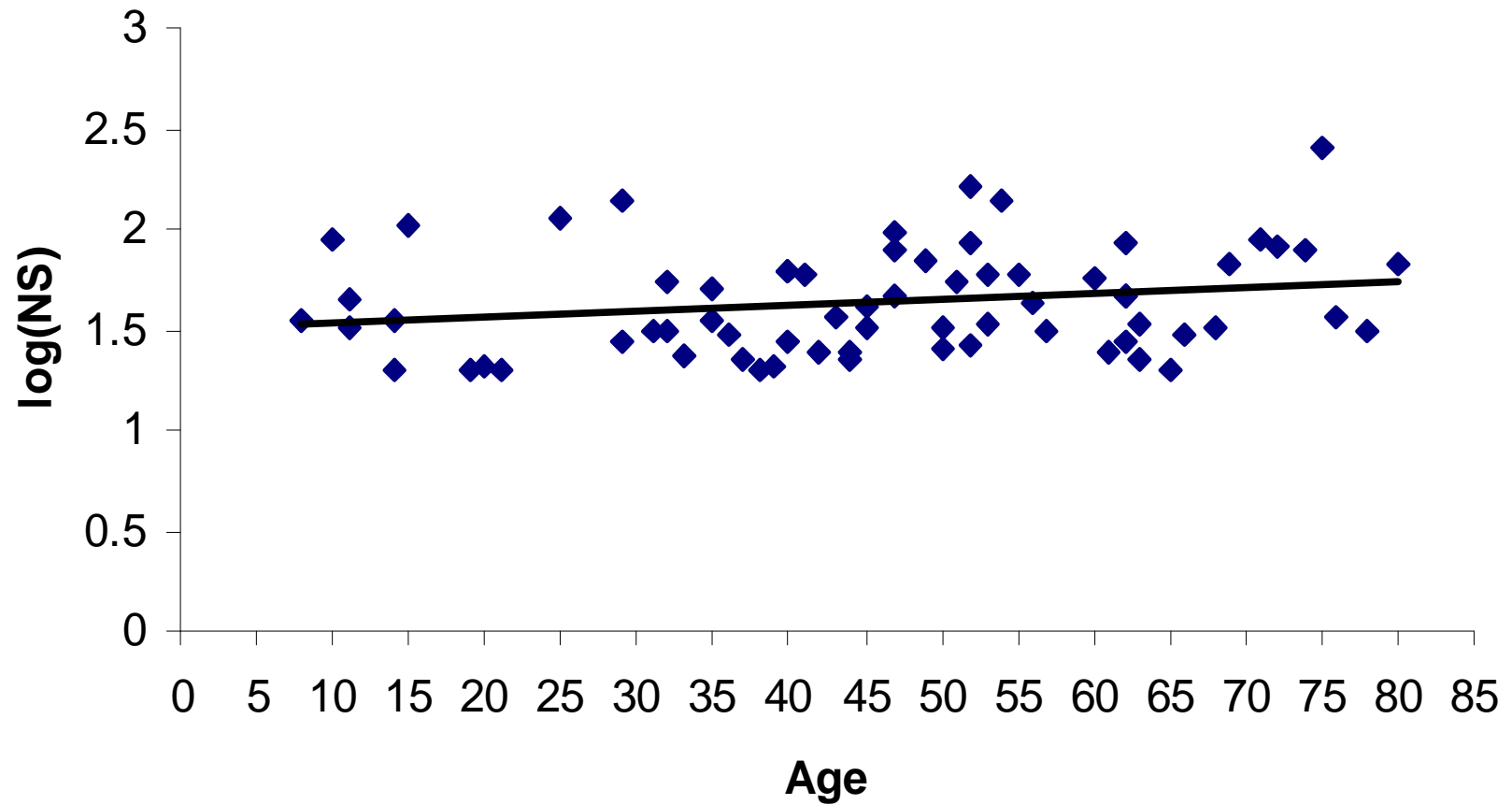


Sex	No of patients	Min	Q1	Me	Q3	Max
Female	40	20	24.5	32	60	250
Male	28	20	31.5	46.5	73.5	164

The differences (based on Kruskal-Wallis test for two groups equivalent to Mann-Whitney test or Wilcoxon Two-Sample Test)

between 32 and 46.5 are not significant ($H=2.314$, $DF=1$, $p = 0.128$)

Age effect on NF efficacy in Pain Management



Conclusions

- Pain or Dolor is one of the 5 symptoms present in inflammation! Explain the use of anti-inflammatory drugs
- After 6 month pain becomes “chronic pain”
- Co-morbidities are aggravating the pain
- “Chronic pain Hurts the Brain, disrupting the default mode network dynamics (DMN)” *Journal of Neuroscience, 2008 p 1398*

Conclusions

- Baliki et al (2008) showed that chronic pain patients present a smaller area of deactivation, suggesting the widespread disruptions of the DMN, explaining the cognitive and behavioral impairments.
- Various electrodes positioning in NF training were found useful, e.g.
 - in acute pain, the area on the homunculus corresponding to the contra-lateral peripheral localization of pain is desired to be trained.
 - in chronic pain, frontal area, corresponding to the unpleasantness of pain is to be trained.

Conclusions

- QEEG evaluations similar to fMRI are guiding NF therapists in choosing the right area of the brain for each individual case.
- The frontal area that deals with the “cumulative memory” in chronic pain syndromes may be modulated through NF.

- There are no differences between the number of NF sessions needed and the gender of our pain population.
- There is no correlation between the age of our pain population and their response to NF modulation on pain perception.
- The number of NF sessions did influence the outcome.
- Twenty NF sessions “were necessary and almost sufficient” to produce positive effects on pain perception and affect.
- Correction of sleep and emotional dysfunctions have also been noted.

Conclusions

- Research and clinical data presented may attest that Neurofeedback is possible to extend the brain innate self-healing process and perhaps re-establish the “default mode network” needed for optimal brain function.
- QEEG and NF must be integrated in medical care of pain sufferers.

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