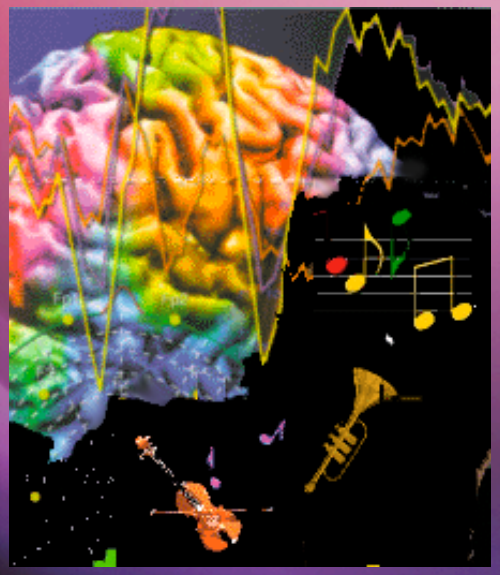
Helping ADHD Children with Music Therapy & EEG Neurofeedback: Brain-jamming for focus



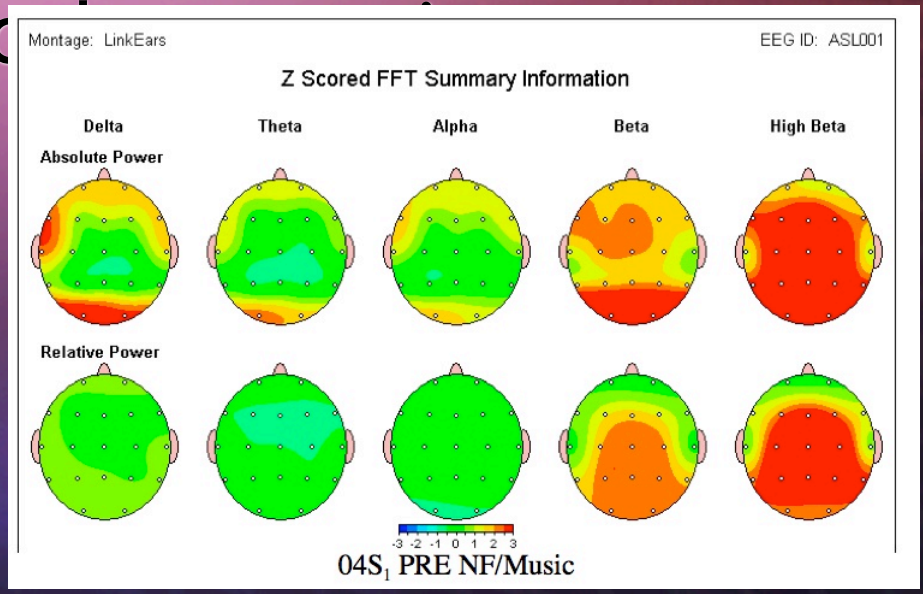
Eric B. Miller

The Biofeedback Network

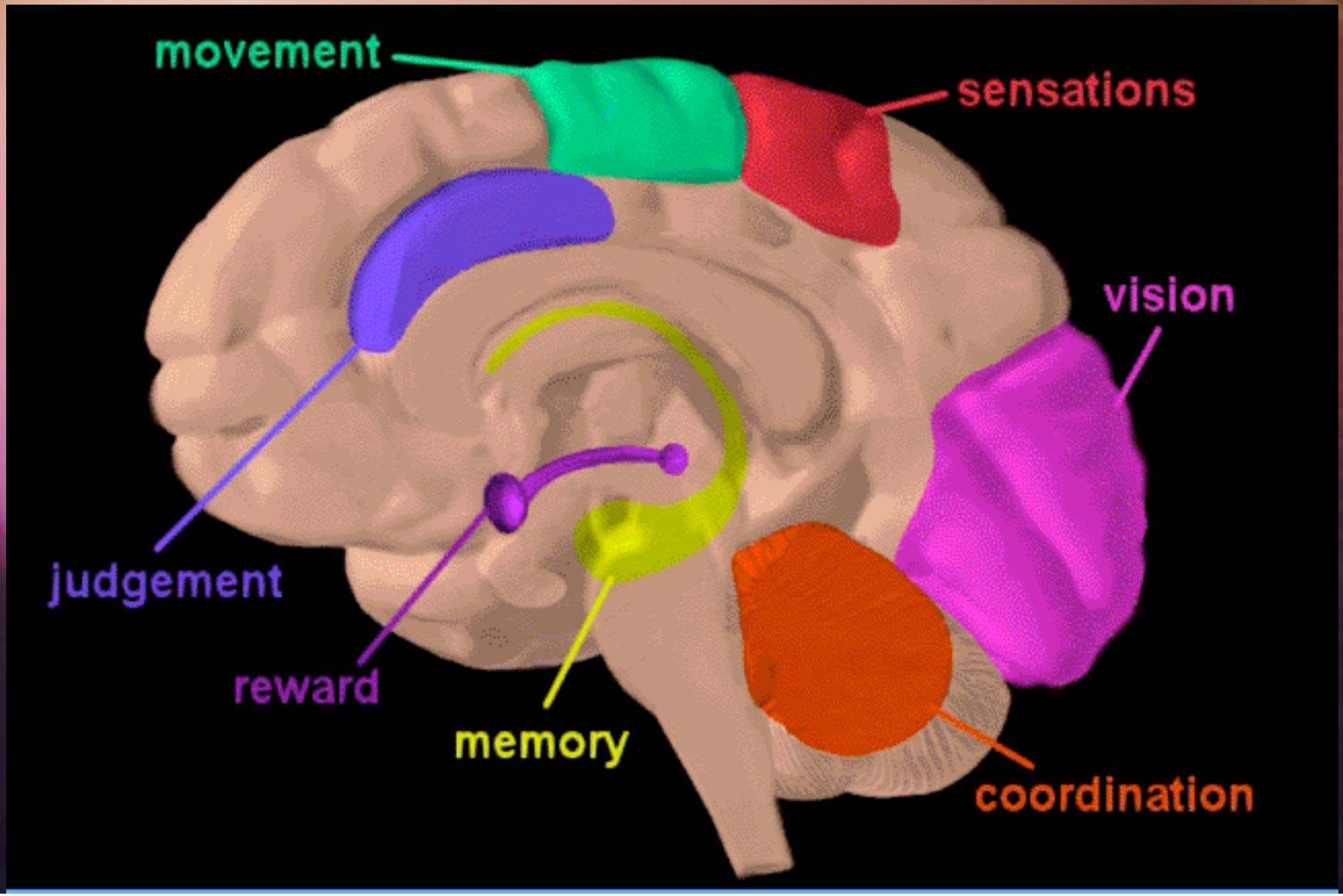
www.Biofeedback.net

OVERVIEW

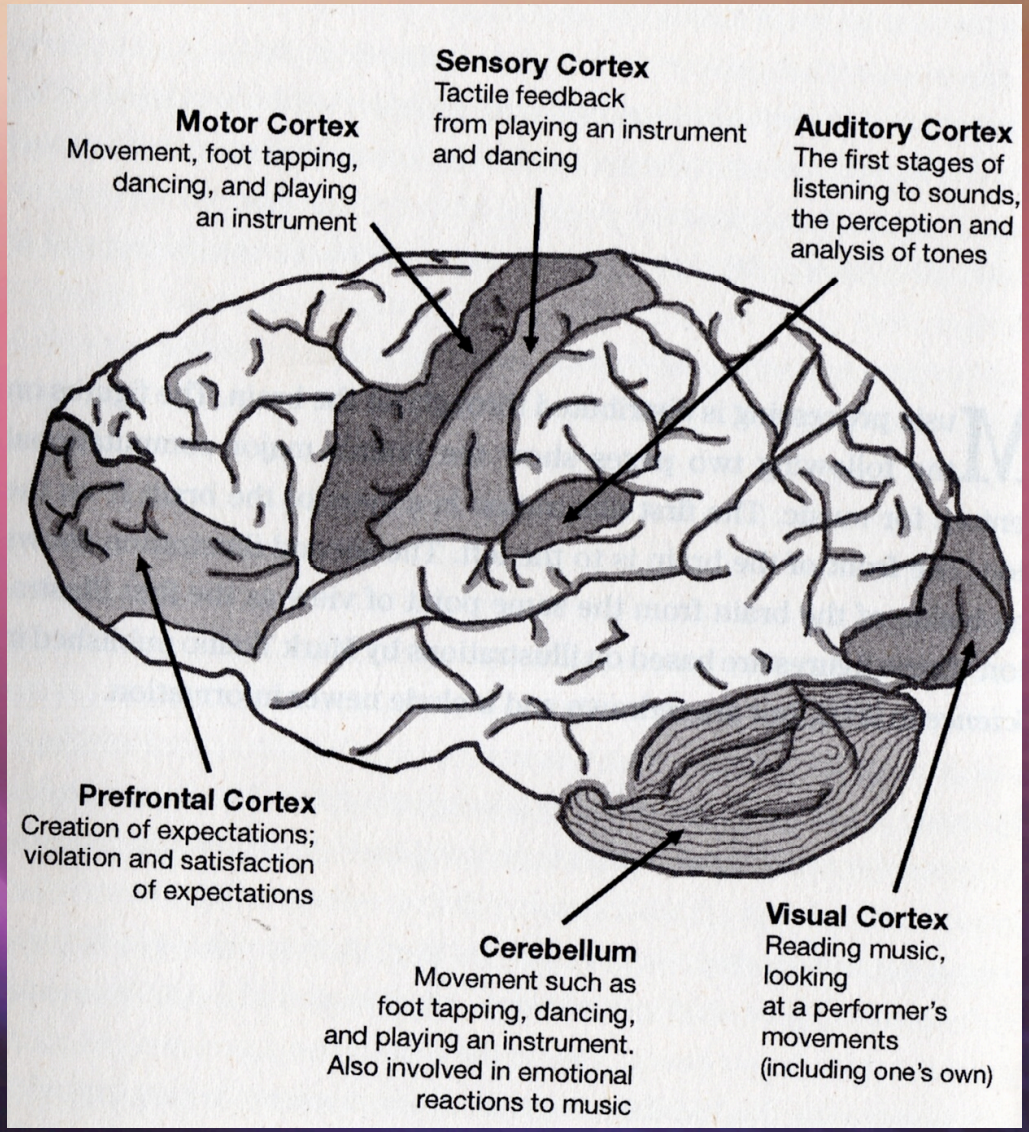
- Building a case for music & NF as treatment modality (how far on the fringe)
- Mechanics of Biofeedback
- Music as physiological system output
- Music as physiologic
- Theories of ADHD
- Pilot Brainmaps
- Pilot Research



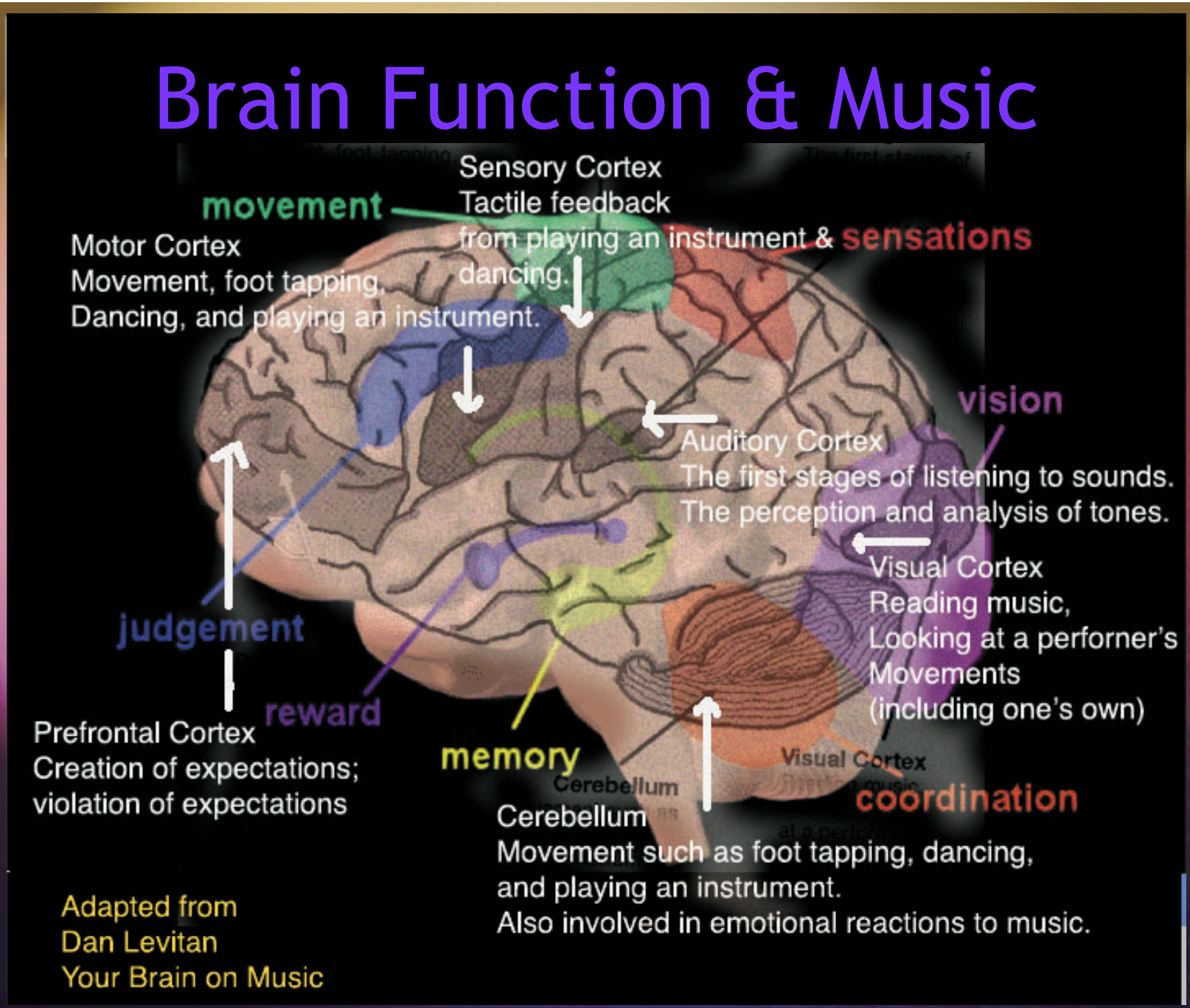
Brain & Function



Brain & Music Function



Brain Function & Music



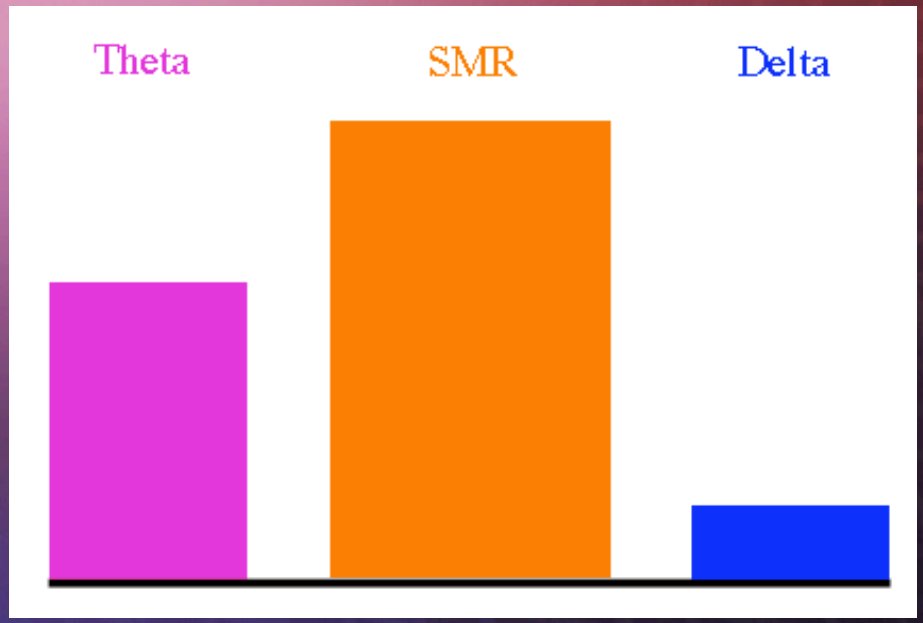
Adapted from
Dan Levitan
Your Brain on Music

Biofeedback Overview

- Biofeedback uses instruments to return immediate physiological information

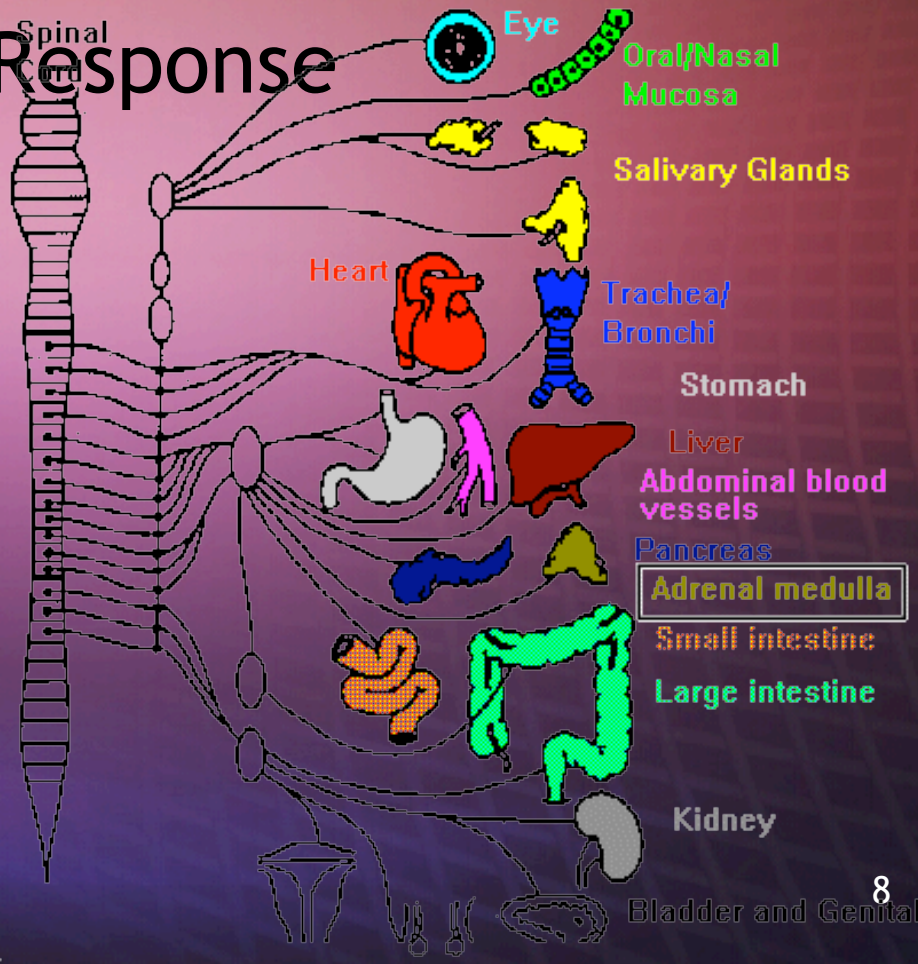
Types of Biofeedback

- EMG
  - Muscles
- Temp
  - Vasculature
- EDG
  - Fight/Flight
- PPG
  - Blood Pulse Volume
- EEG
  - Brainwaves

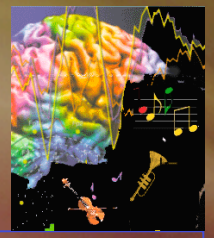


Targeting the Sympathetic Nervous System

- Sympathetic/ Parasympathetic Response



Biofeedback is



- a learning process which helps you gain control of your body's responses to stress, anxiety, physical strain and emotional stimuli.
- is the use of instruments to reflect physiological conditions. With this information, a person may be able to effect change upon body areas previously not under volitional control.
- can monitor muscle tension, heart-rate, blood pressure, peripheral blood flow (vasoconstriction) and galvanic skin response, EEG brain waves and others.
- is a non-invasive, client-centered method of training the body in which the learner actively participates in treatment and the doctor or therapist assumes the role of coach.
- is practiced by physicians, nurses, psychologists,psychiatrists, chiropractors, social workers, dentists, music therapists, and other health practitioners. A typical course of treatment may run 8-16 sessions or until mastery is achieved.

EMG

- Tension Headaches
- Neck & Back Pain
- Hypertension
- Anxiety
- General Stress
- Phobias
- Neuromuscular Reeducation
- Stroke
- Bruxism
- Temporomandibular Joint Syndrome

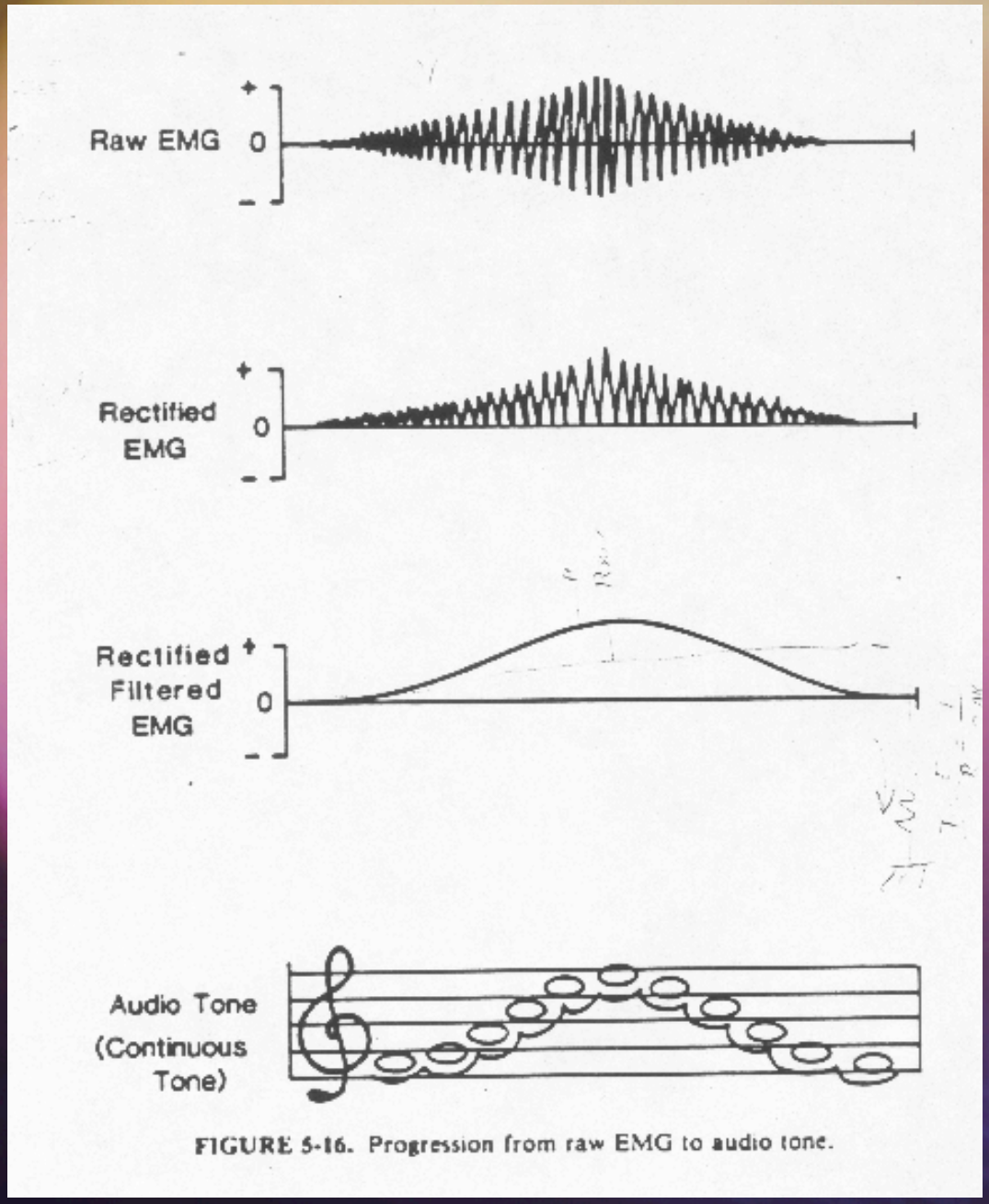
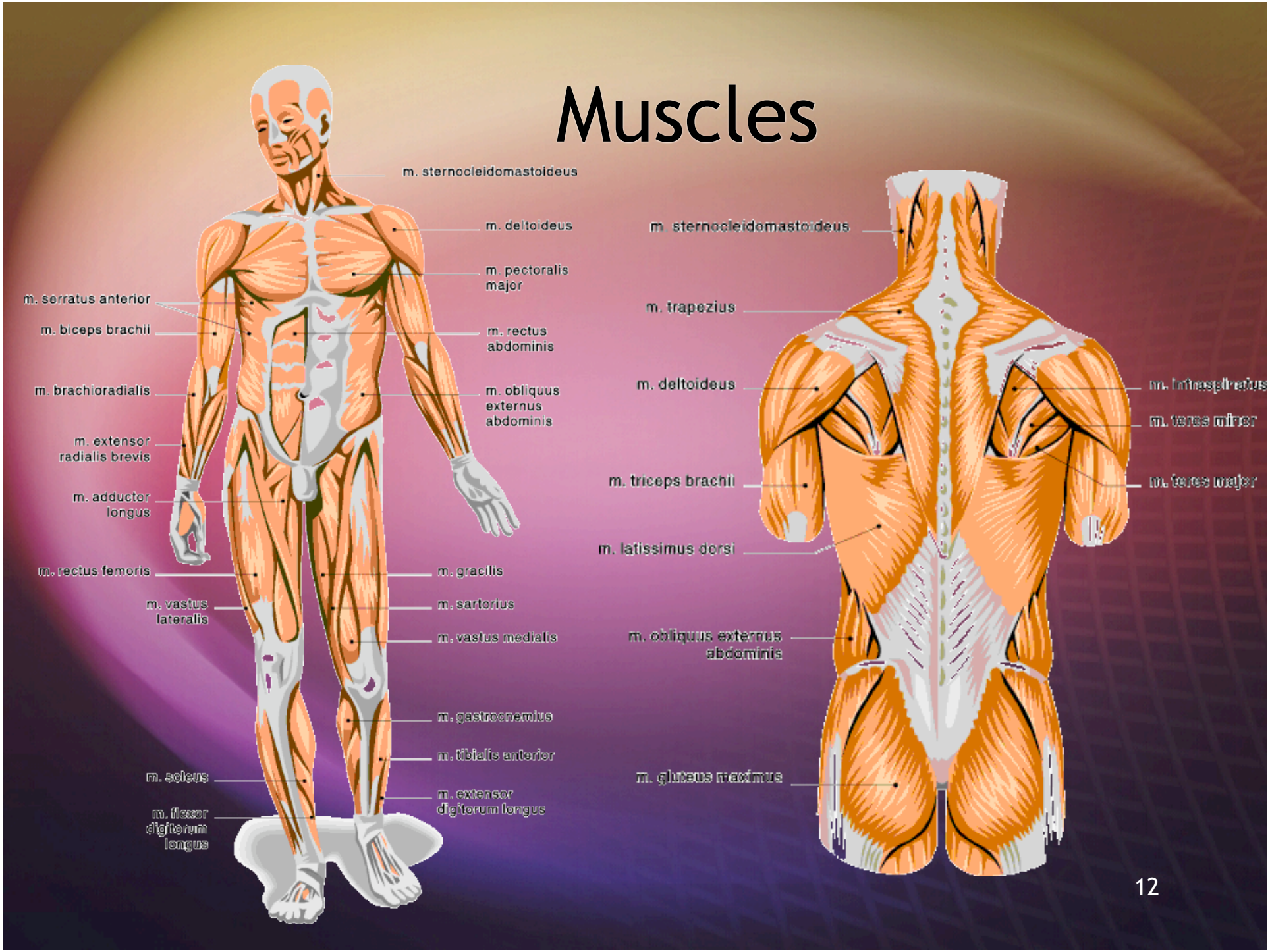


FIGURE 5-16. Progression from raw EMG to audio tone.

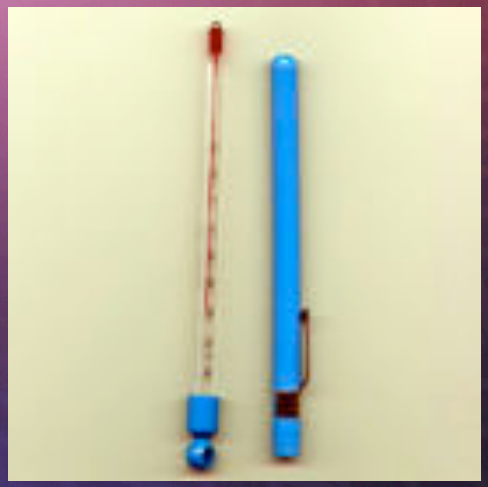
EMG

Muscles


m. sternocleidomastoideus
m. deltoideus
m. pectoralis major
m. serratus anterior
m. biceps brachii
m. rectus abdominis
m. brachioradialis
m. obliquus externus abdominis
m. extensor radialis brevis
m. adductor longus
m. rectus femoris
m. gracilis
m. vastus lateralis
m. sartorius
m. vastus medialis
m. gastrocnemius
m. tibialis anterior
m. soleus
m. extensor digitorum longus
m. flexor digitorum longus
m. sternocleidomastoideus
m. trapezius
m. deltoideus
m. triceps brachii
m. latissimus dorsi
m. obliquus externus abdominis
m. gluteus maximus
m. teres major

Temp

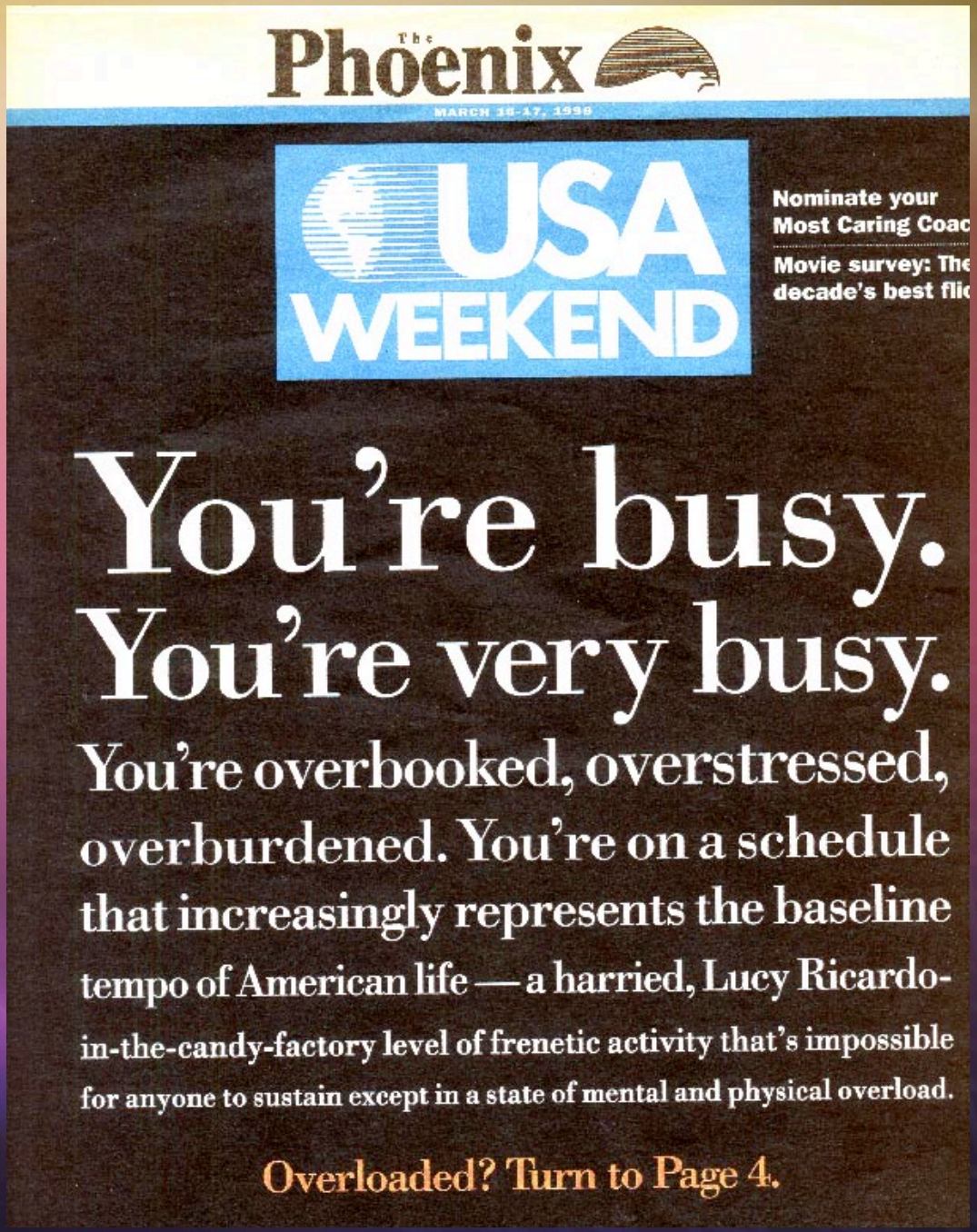
- Migraine Headaches
- Raynaud's Disease/
- Peripheral Vascular
- Resistance in psychotherapy
- Asthma/ Hypertension



EDG

- Systematic Desensitization
- Guided Imagery/ Exploratio
- Stuttering
- Asthma
- Stress
- Phobias

Sweat glands respond to anxiety & perceived danger. This fight/flight reaction is measured by the Electrodermograph (EDG) Training can assist with the following:


The Phoenix
MARCH 16-17, 1990
USA WEEKEND
Nominate your Most Caring Coac
Movie survey: The decade's best flic
You're busy.
You're very busy.
You're overbooked, overstressed, overburdened. You're on a schedule that increasingly represents the baseline tempo of American life — a harried, Lucy Ricardo-in-the-candy-factory level of frenetic activity that's impossible for anyone to sustain except in a state of mental and physical overload.
Overloaded? Turn to Page 4.

stress

- Physical Demand
- Emotional Demand
- Perceived Danger
- Ambiguity/Uncertainty
- Habituated Response
- Cognitive Interpretation

"…understanding, identifying, and treating problems of youth must draw on multiple disciplines and diverse views within a given discipline"

(Alan E. Kazdin, Ph.D., 1988, p. 8).

The Center for Disease Control & Prevention (CDC) describes ADHD as "a neurobehavioral disorder characterized by pervasive inattention and/or hyperactivity-impulsivity and resulting in significant functional impairment" (CDC, 2005, p. 1).

CONTEMPORARY THEORIES OF ADHD

The DSM-IV offers three subtypes of ADHD:

- 314.01 Attention-Deficit/Hyperactivity Disorder, Combined Type;
- 314.00 Attention-Deficit/Hyperactivity Disorder, Predominantly Inattentive Type;
- 314.01 Attention-Deficit/Hyperactivity Disorder, Predominantly Hyperactive-Impulsive Type (APA, 1994, p. 85).

CONTEMPORARY THEORIES OF ADHD

The symptoms of ADD (ADHD - H) include six or more of the following symptoms of inattention that have persisted for at least 6 months to a degree that is inconsistent with the developmental level:

1. Often fails to give close attention to details; makes careless mistakes in school or other activities
2. Often has difficulty sustaining attention in tasks or play activities
3. Often does not seem to listen when spoken to directly
4. Often does not follow through on instructions and fails to finish chores or duties
5. Often has difficulty organizing tasks and activities
6. Often avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort
7. Often loses things necessary for tasks or activities
8. Is often easily distracted
9. Is often forgetful in daily activities

CONTEMPORARY THEORIES OF ADHD

The symptoms of ADHD (ADD + hyperactivity) include six or more of the following symptoms of hyperactivity-impulsivity that have persisted for at least six months to a degree that is not consistent with the developmental level:

1. Often fidgets with hands or feet or squirms in seat
2. Often leaves seat in classroom or other setting where sitting is required
3. Often runs about or climbs in situations in which it is inappropriate
4. Has difficulty playing or engaging in quiet leisure-time activities
5. Is often “on the go” or acts as if “driven by a motor”
6. Often talks excessively
7. Often blurts out answers before question has been completed
8. Has difficulty awaiting turn
9. Often interrupts or intrudes on others (butts into conversations or games)

(APA, 1994). The above set of indicators used in the DSM-IV is utilized by schools, insurance companies and mental health practitioners.

CONTEMPORARY THEORIES OF ADHD

Behavioral Inhibition

The Quay/Gray theory of behavioral inhibition posits that ADHD arises from reduced activity in the behavioral inhibition system (BIS) of the brain (Barkley, 1999).

Approach behavior (positive reinforcement) arises from reward signals increasing activity in the behavioral activation system (BAS), while avoidance behavior (negative reinforcement) also activates this same system

CONTEMPORARY THEORIES OF ADHD

Executive Functions

The Barkley/Bronowski theory of executive functions offers a unifying theory of ADHD (Barkley, 1999). Building on the Quay/Gray theory, Barkley agrees that ADHD arises from a deficiency of inhibition located in the pre-frontal cortex and goes on to delineate four types of executive functions that are diminished by the lack of behavioral inhibition, contributing to the disruption of goal-directed motor behavior and self control.

CONTEMPORARY THEORIES OF ADHD

Barkley's 4 types of executive function:

1. Nonverbal Working Memory,

in which ADHD children have difficulty holding on to current unspoken information. This leads to difficulty carrying information forward from the past to the future, resulting in diminished hindsight, foresight, self-awareness and poor planning.

2. Internalization of Speech (verbal working memory), in which children who are older than pre-school age (who would normally use self-speech for self-regulation) are less able to so. This leads to a reduction in the ability to use information from task failures to inform future performance and diminishes problem-solving abilities.

CONTEMPORARY THEORIES OF ADHD

Barkley's 4 types of executive function:

3. Self-Regulation of Affect, Motivation and Arousal, in which ADHD children are missing the mentally represented forms of information that typically serve as "the drive in absence of external reward that fuels the individual's persistence in cross-temporal behaviors and thereby bridges the delay to the future reinforcer" (Barkley, 1999, p. 309). This results in a lesser ability for ADHD children to create positive emotional states through self-talk and imagery in the face of frustrating or disappointing events. Since the internalization of emotional processing is delayed, outward or public expressions are manifest in ADHD children.

4. Reconstitution,

in which the recombining of informational units of behavior is deficient in ADHD children, leading to difficulties with the syntactical relations involved in temporal sequencing, e.g., if-then relationships.

CONTEMPORARY THEORIES OF ADHD

Barkley's 4 types of executive function:

Barkley goes on to distinguish between two types of attention – that which is "contingency-shaped" and that which is "self-regulated and goal directed" (Barkley, 1999, p. 310), arguing that the former is not impaired in ADHD children, whereas the latter is impaired.

ADHD is the most frequently diagnosed childhood disorder in the United States

- It is estimated that 3-5 percent of all children suffer from ADHD, approximately 2 million children (NIMH, 2006).

and ADHD Continues into Adulthood

- “It is estimated that between 30% and 50% of children diagnosed with attention deficit hyperactivity disorder (ADHD) will continue to exhibit symptomatology that is disruptive throughout their adult lives” (Jackson & Farrugia, 1997, p. 312).
- Between two to five million adults suffer from ADHD (C.H.A.D.D., 2004), for whom relatively little attention is given.

ADHD Treatment

Most physicians prefer to administer psycho-stimulants (NIMH, 1998). Common agents include:

- Methylphenidate (Ritalin),
- Dextroamphetamine (Dexedrine),
- Dextroamphetimine/amphetamine (Adderall),
- Methamphetamine (Desoxyn)
- Pemoline (Cylert)
- Bupropion (Wellbutrin)
- Sertraline (Zoloft) (Manisses, 1997).

Ritalin

is similar to cocaine, and
is on the DEA's list
of dangerous narcotics

Response to Medication

- Approximately 70 - 80% of ADHD children treated with medication respond favorably to stimulants (Barkley, 1990; Barkley & Loo, 2005).

- The effects, however, last only while the medication is being taken (NIMH, 2006).

Response to Medication

- Patterns of excessive frontal slow wave activity occur in the brains of ADHD children and are remedied when ADHD children take the stimulant methylphenidate (Loo, Teale & Reite, 1999).
- NF researchers demonstrate not only the ability to alter brainwave states through training sessions, but also claim behavioral improvements in ADHD symptoms (Monastra, 2003; Doggett, 2004).

MTA Study of 1992

- In 1992, the NIMH conducted the landmark Multimodal Treatment of Attention-Deficit Hyperactivity Disorder study (MTA) that looked at four types of treatments in 579 subjects (Jenson, et al, 2001).
- The four groups included:
- routine Community Care (CC),
- Medication Management (MedMgt),
- Behavioral treatment (Beh) and,
- in addition, a Combination (Comb).

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- Medication Management (MedMgt),
- Behavioral treatment (Beh) and,
- in addition, a Combination (Comb).

MTA Study of 1992

The superior effects of Comb and MedMgt groups, diminished at a 24-month follow-up by 50%, while the Beh and CC groups did not regress.

The subgroup that ceased medication treatment exhibited the most deterioration.

Additionally, while medication initially appeared superior, consumer parent-teacher ratings favored behavioral treatment (NIH, 2004).

Ritalin Conspiracy? Multi-million dollar industry!

- a class action law suit was filed in Texas, charging the Ciba Geigy Corporation, U.S.A., Novartis Pharmaceuticals Corporation, Children and Adults With Attention-Deficit/Hyperactivity Disorder (CHADD), and the American Psychiatric Association with fraud and conspiracy to promote the diagnosis of Attention Deficit Disorder within the context of a successful effort to increase sales of the product Ritalin.

Ritalin Sales in millions of dollars

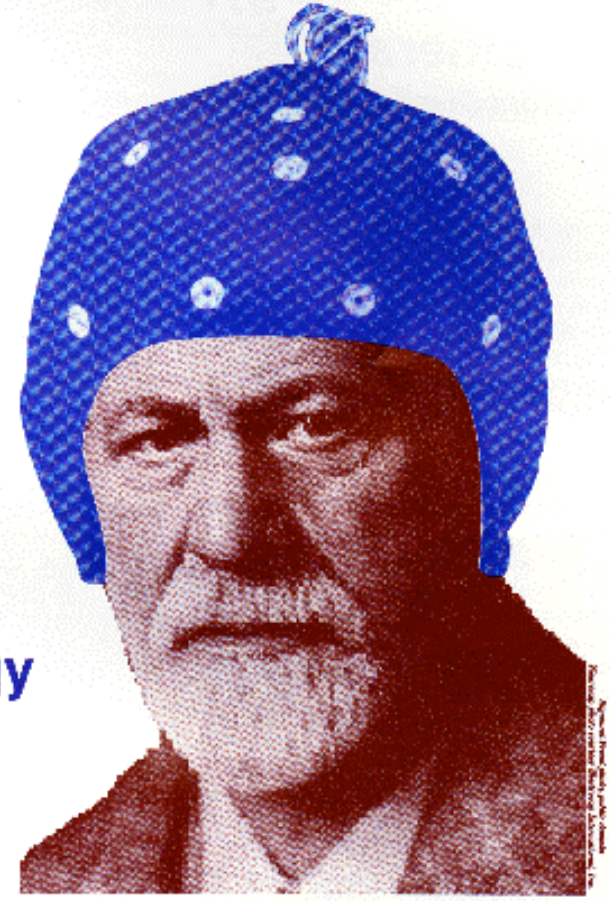
BIOFEEDBACK

Volume 26, Number 1 Spring 1998

Newsmagazine of the Association for Applied Psychophysiology and Biofeedback

Special Issue:

- Biological Monitoring
- Applied Psychophysiology
- Psychotherapy



Sigmund Freud

EEG: A non-drug Alternative

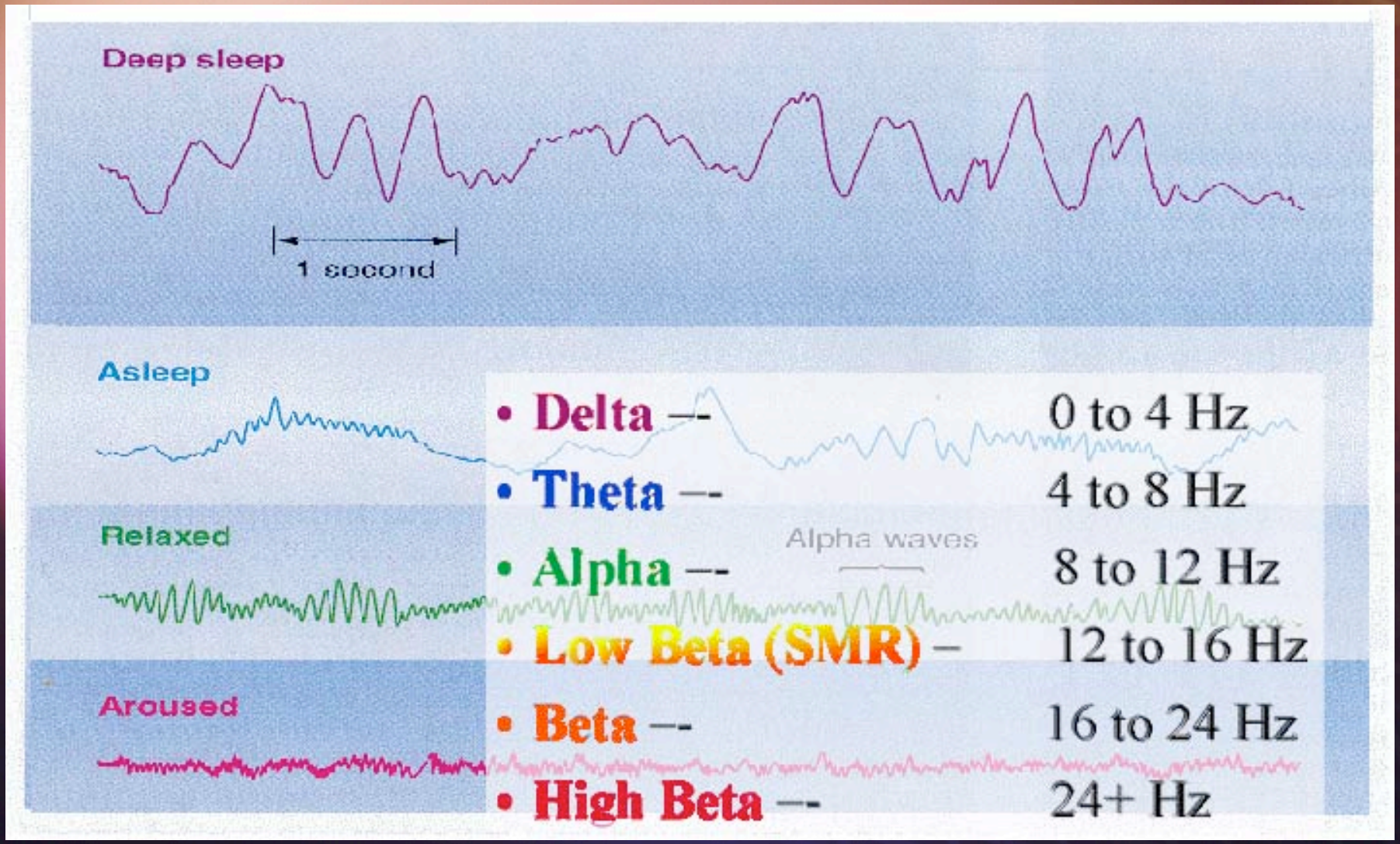
Research Questions:

- **Can Neurofeedback help improve cognitive functioning and academic performance in ADHD Children?**
- **Can better use of MUSIC and audio maximize the effect of NF for kids?**
- **How much money can these strategies save the school districts?**

Bio-Medical Paradigm Models

- Pre-frontal Cortex development
- BIS: Behavioral Inhibition System
- Low cortical arousal
- Inability to modulate arousal levels
- Deficits in organization
- Non-verbal working memory

Brainwave Patterns



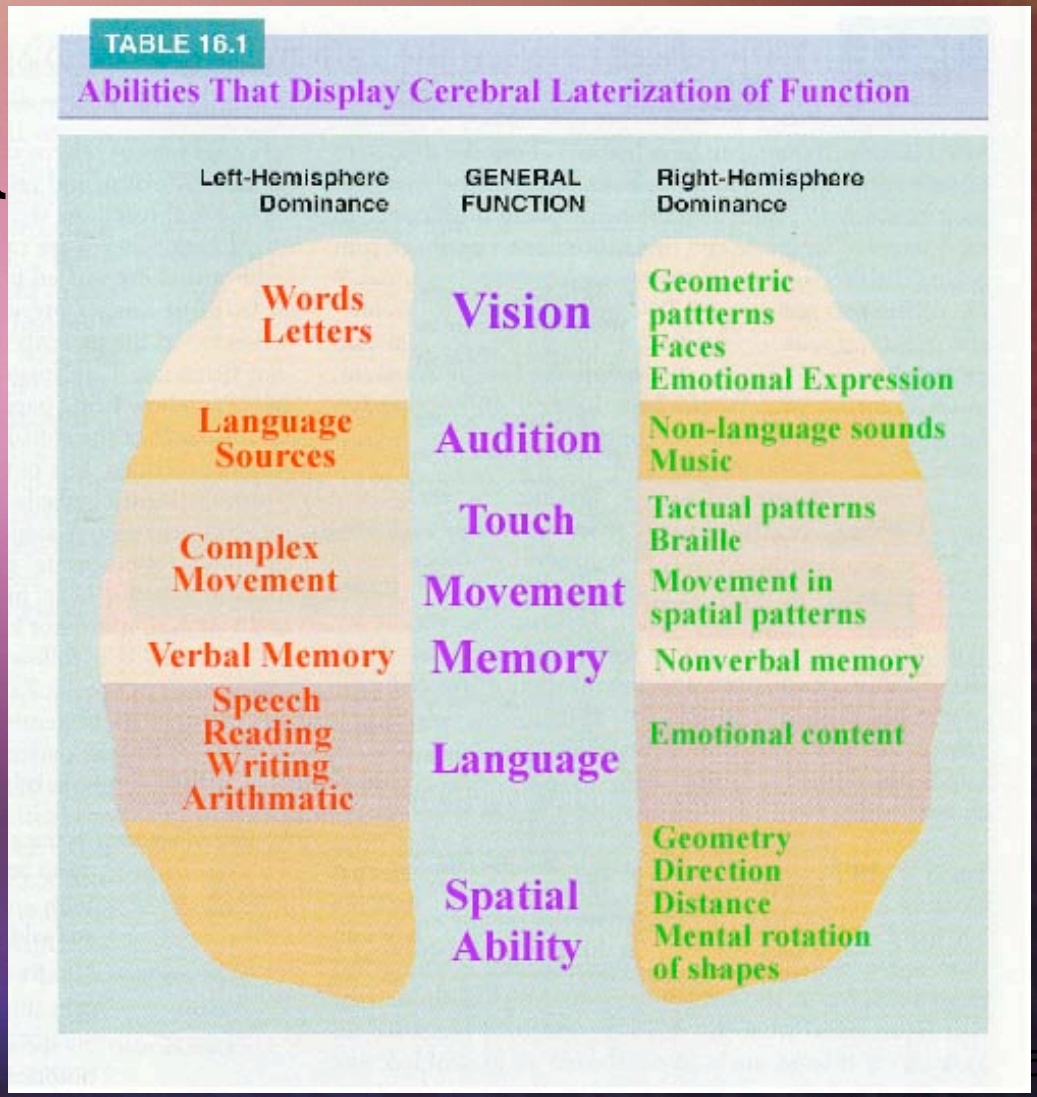
3 Major Axes of Functioning

- Anterior-Posterior
- Lateral
- Cortical/Subcortical

Anterior (Frontal Lobes) govern Expressive Skills

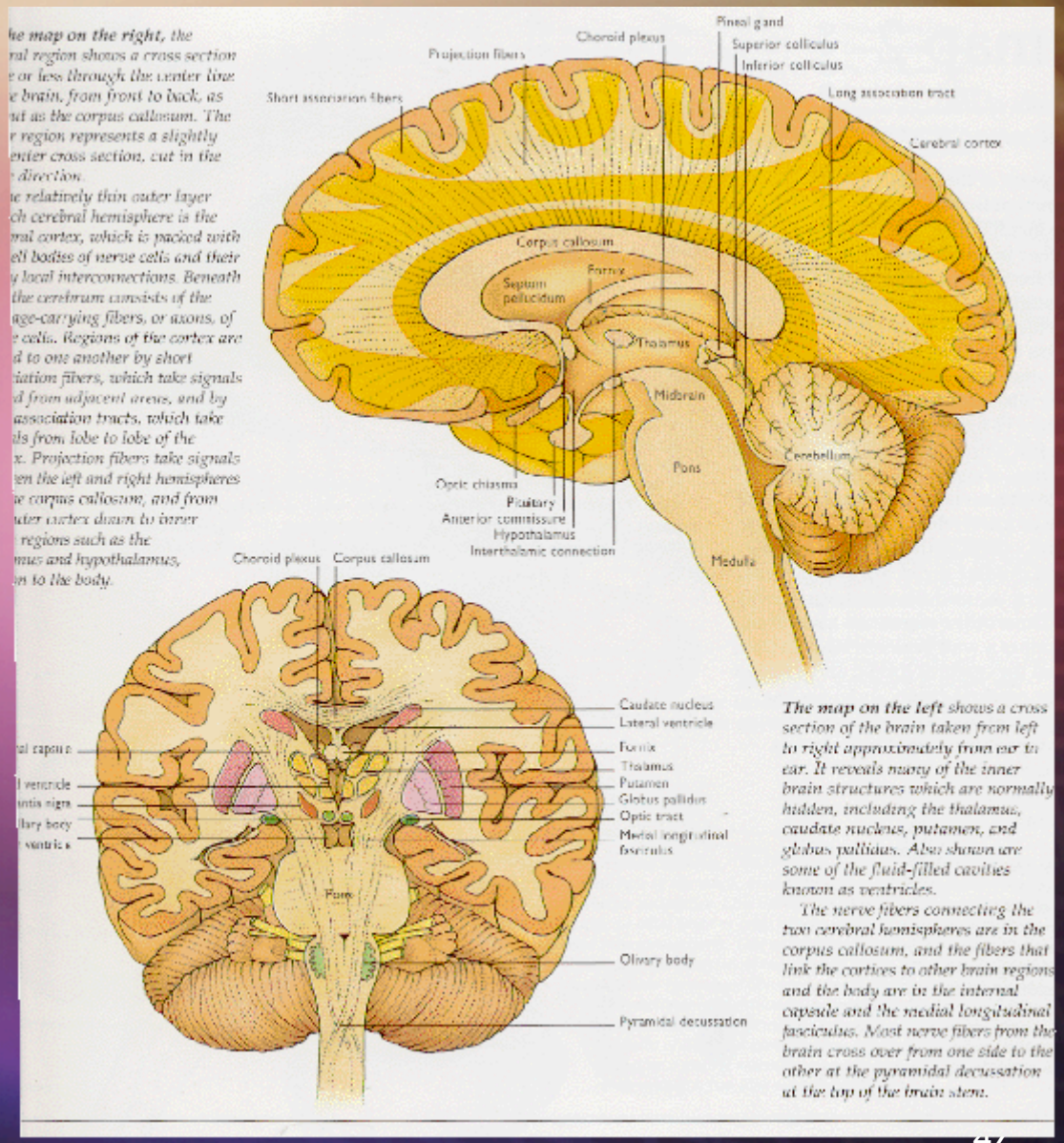
Posterior (Parietal, Temporal and Occipital Lobes) govern Receptive Skills

Left-Right Brain Functions



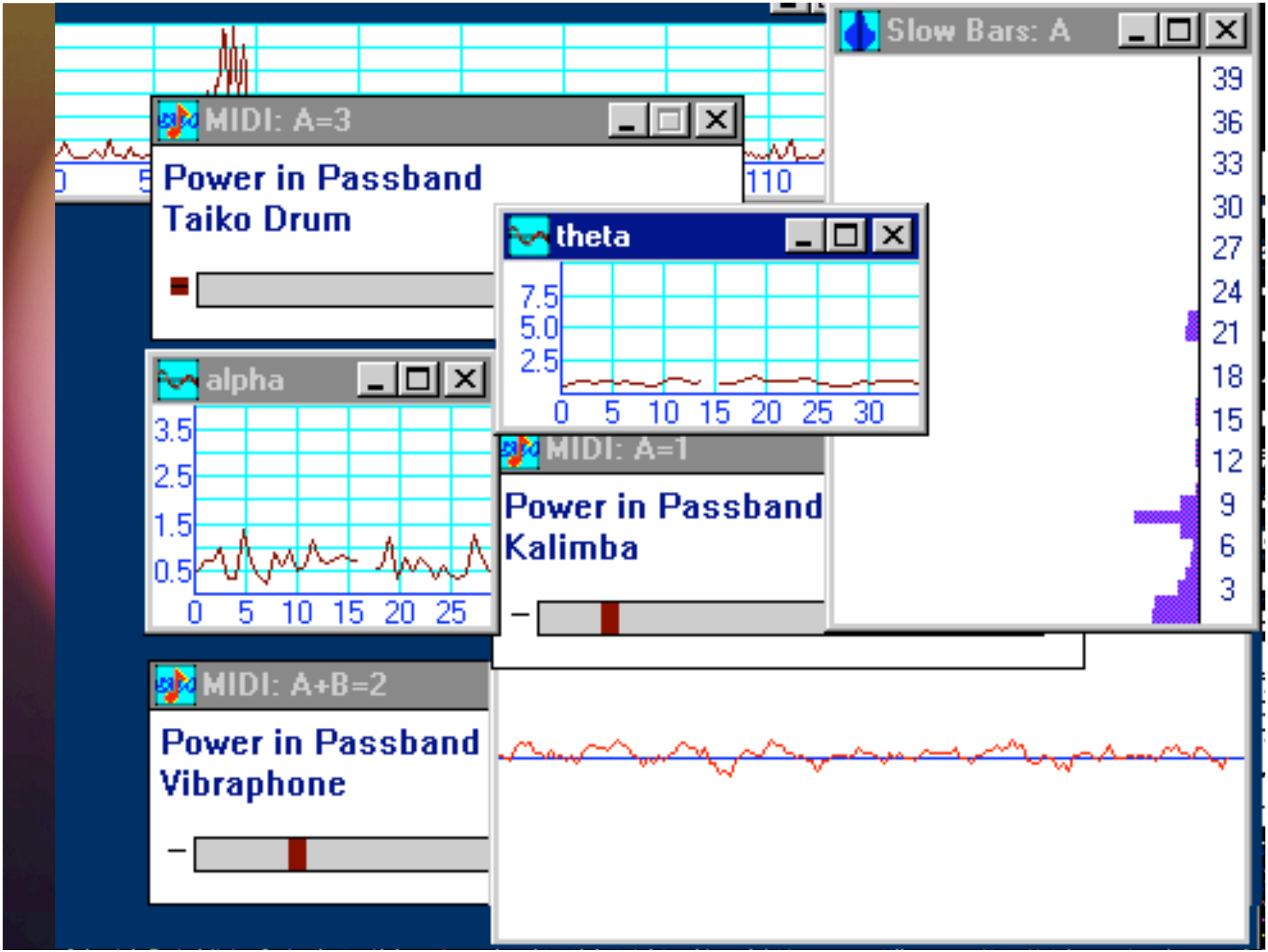
Cortical and Subcortical Activity

- Cortical activity governs higher-level types of function: sophisticated thought processes,physical expression, subtle emotional responses, creativity, etc.
- Subcortical activity governs basic, autonomic function: physiological arousal, metabolic processes, basic emotional tone

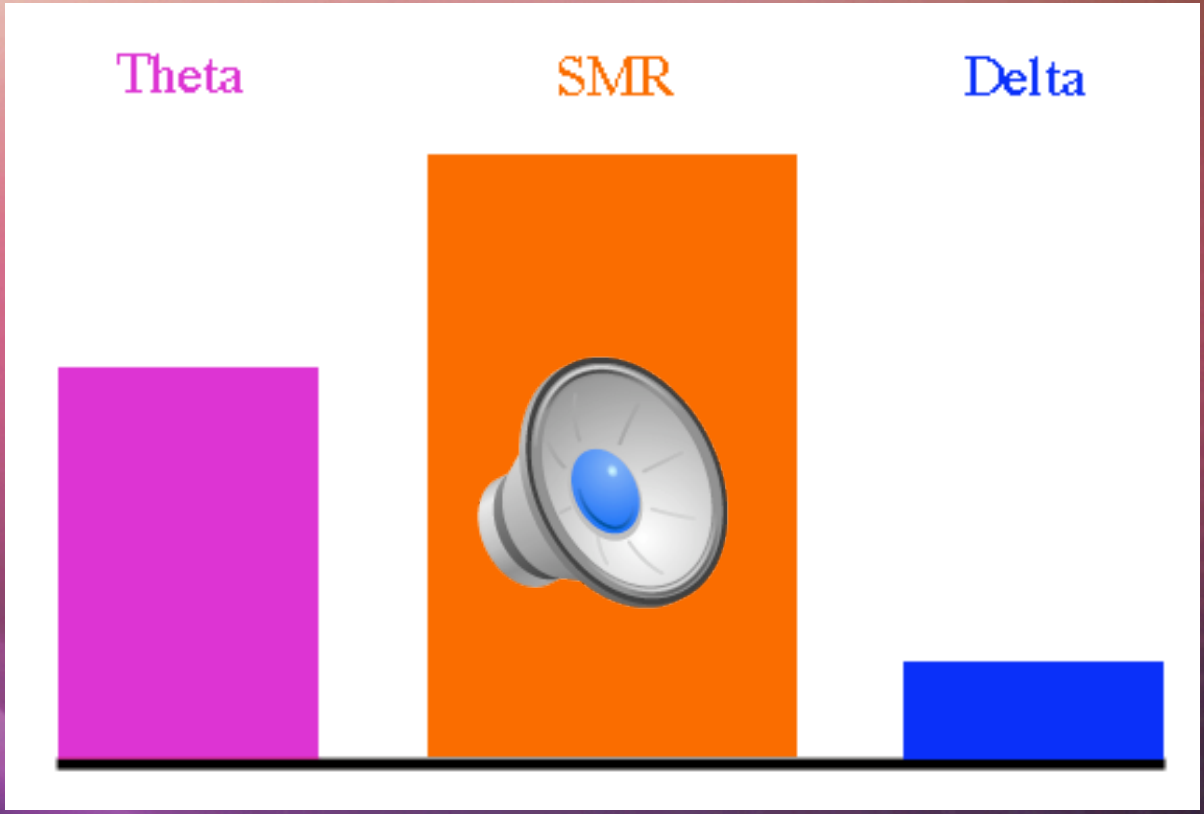


ADHD & Biofeedback

- **Reducing Theta** (4-7Hz) brain rhythms & Increasing SMR (12.5-15 Hz) brain rhythms Reduces symptoms of ADHD in both children and adults (Sterman, 1977; Lubar, 1991; Lubar, 1997; Kuperman, 1996; Tansey & Bruner, 1983; Tansey, 1984, 1985, 1990; Carter & Russell, 1985; Othmer, 1998)
- Non-pharmacological.
- Non-invasive.
- Not cheap.


MIDI: A=3
Power in Passband
Taiko Drum
theta
7.5
5.0
2.5
0 5 10 15 20 25 30
alpha
3.5
2.5
1.5
0.5
0 5 10 15 20 25
MIDI: A=1
Power in Passband
Kalimba
MIDI: A+B=2
Power in Passband
Vibraphone
Slow Bars: A
39
36
33
30
27
24
21
18
15
12
9
6
3
110

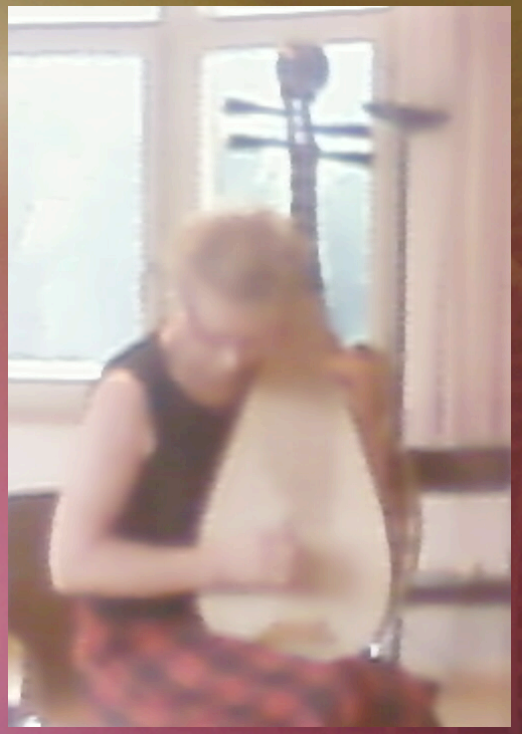
EEG Training Screen



Star Wars Neurofeedback

Star Wars Neurofeedback

Role of the Music Therapist



- Creation of musical menu
- Develop musical designs
- Choice of key, scale & instrument
- Maintain integrity of musical environment
- Adapt musical protocols to client

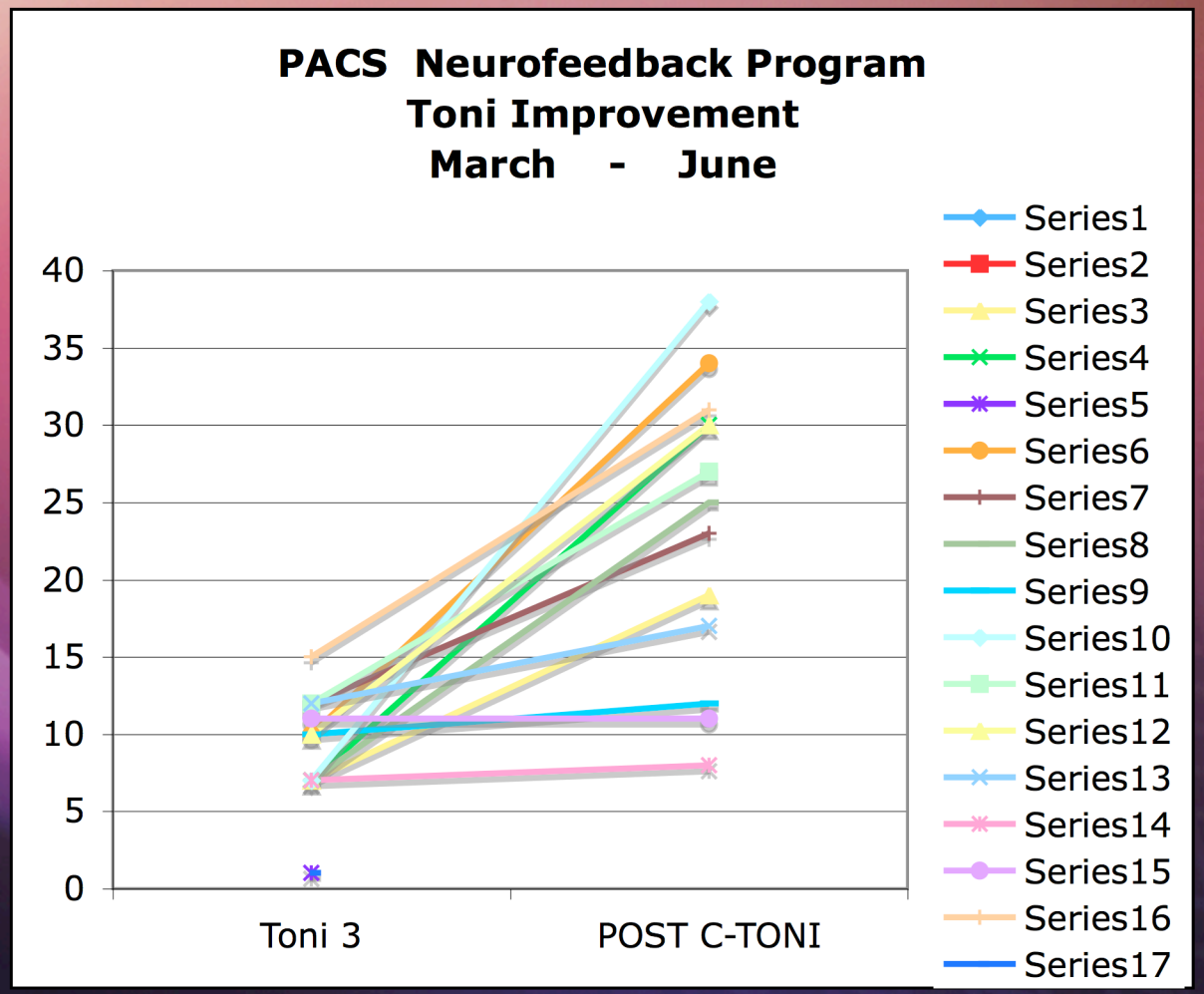
CMO Configuration

Context: **ADHD kids successfully completing the NF program**

Mechanism: **NF & Music training increases student's self-regulation skills and increases sense of academic ability (shift in locus of control)**

OUTCOME: Increase in self-esteem and belief in ability to perform at a higher academic level resulting in improved grades.

Toni Scores Pre and Post



Inclusion Criteria

- **8-14 years old** & collateral data from their parents, teachers, healthcare professionals.
- **Formally diagnosed** with ADHD by a licensed psychologist, psychiatrist or medical doctor with or without the “H”.
- **Does Not have other axis 1 Dx**
- **Not taking medications** that would confound the EEG

Measures

- The Conners' CPT
- Stroop, Nepsy exec sub-scale, Toni-3
- Quantitative electroencephalography (QEEG)
- Monopolar EEG session data
- Pre, mid and post-session questionnaires
- Qualitative interviews

Potential Impediments

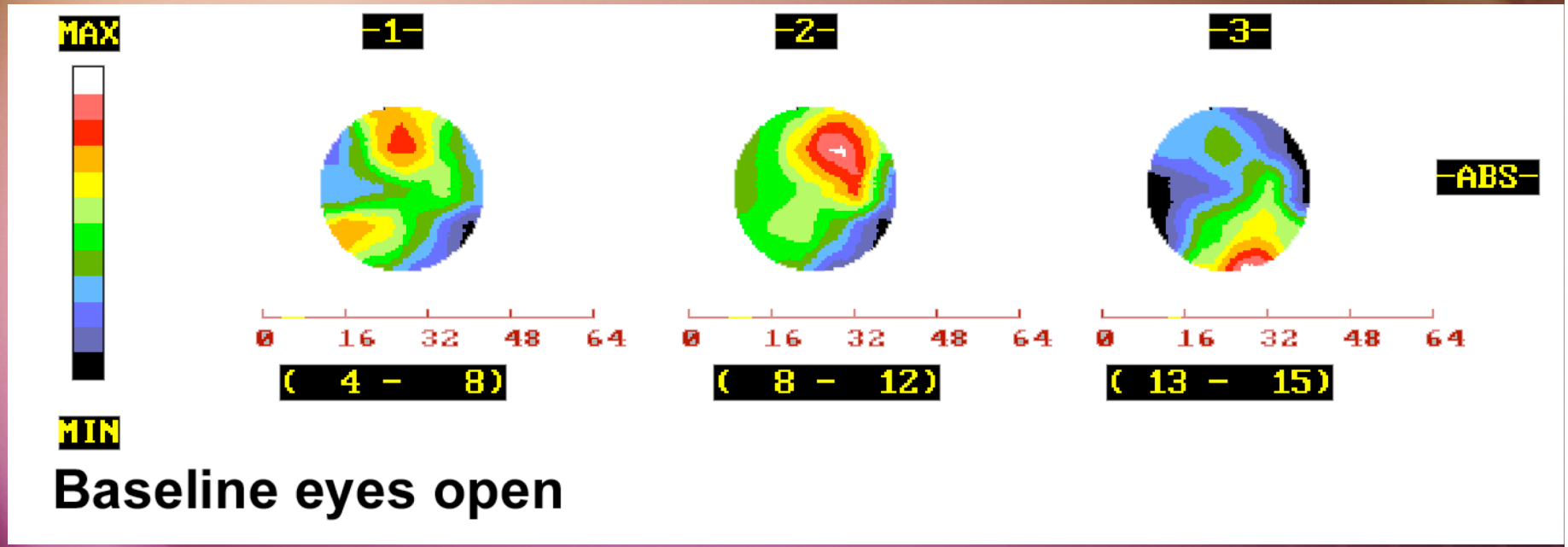
- Co-morbid symptomatology
- Inter-subject variability
- Aesthetic preferences
- Reporting accuracy

Potential Outcome

- **Development of a more accessible and affordable non-drug treatment protocol than presently exists for ADHD by integrating an active musical component into EEG treatment.**
- **Over $1,000,000 dollars in savings to the school districts over 3 years.**

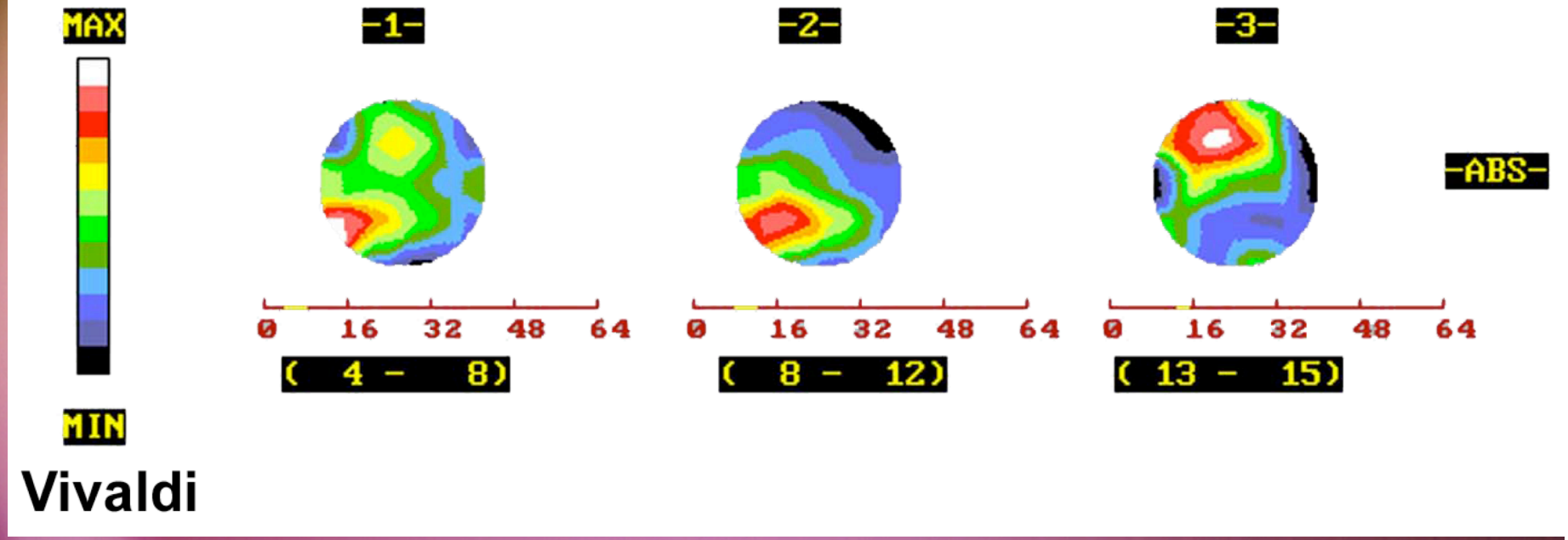
*** Based on the Yonkers NY School program**

EEG Map - Baseline



The first QEEG brain map shows "hot" Theta and Alpha in the frontal region of this 7 year ADHD child's brain during an eyes-open baseline reading.

EEG Map - Vivaldi

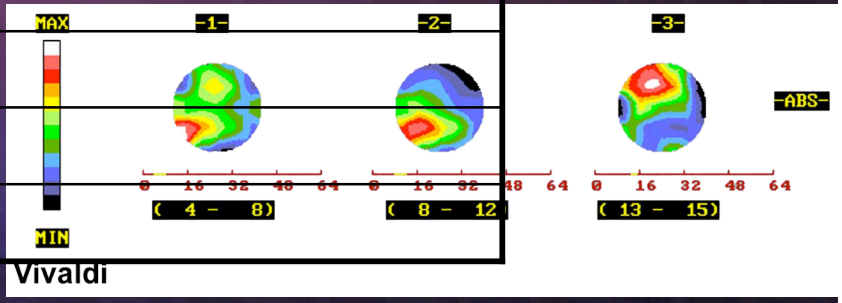


Vivaldi

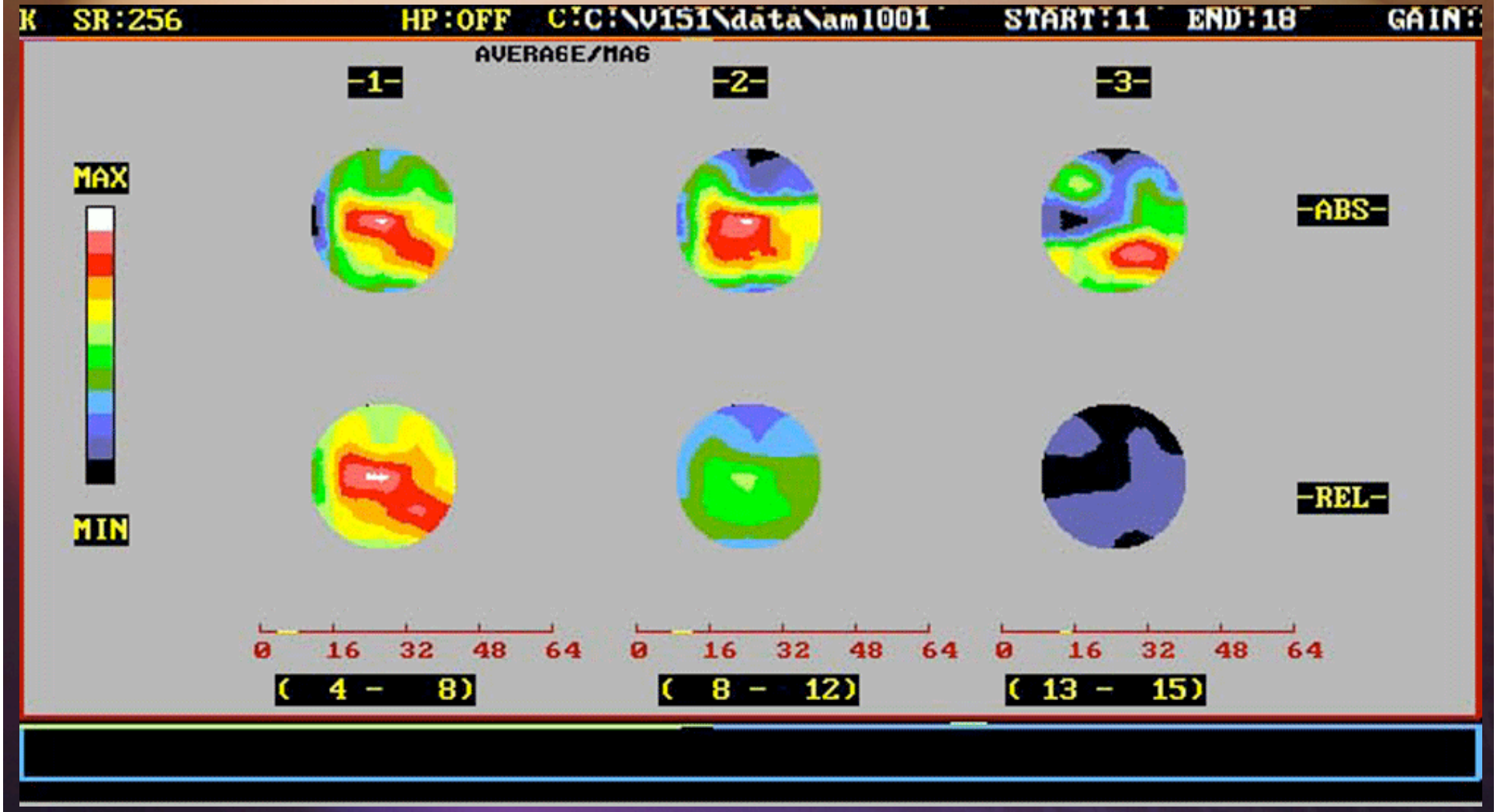
The second QEEG Brain map (Figure 9), shows reduced Theta and Alpha rhythms with increased Sensori-motor Rhythm (SMR), a low Beta wave, while the same child listens to Vivaldi. This pattern is more likely to correlate with increased attention. These are just illustrative snapshots (averaged over 2 seconds) from the current research project, and do not mean much until the entire length of each condition is averaged and graphed. What is exciting here is the method, and finding new ways to assess and analyze brain activity.

EEG - Assessment

	Assessment	Time
1	Baseline EYES OPEN	2 min
2	Baseline EYES CLOSED	2 min
3	Listening	1 min
4	Reading	1 min
5	Training	2 min
6	Visual Stim (Art)	1
7	music listening 1 Class	1
8	music listening 2 Slow	1
9	music listening 3 Rhy	1
10	Motion/ no music	1
11	Music Improvisation	1
12	Final Post-Base	2 min
	Total	16min



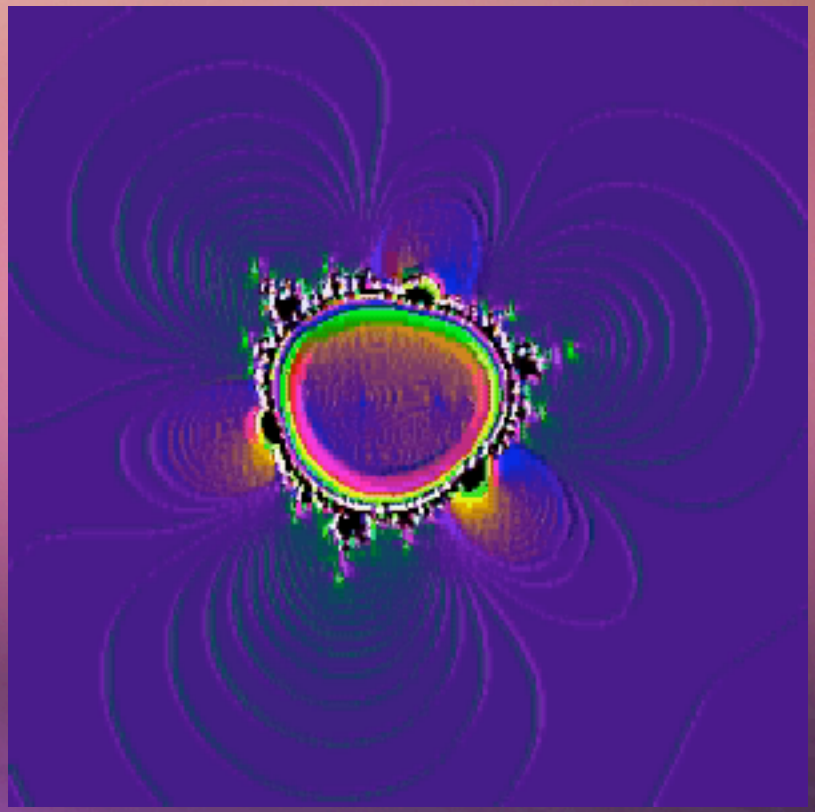
EEG/Music Assessment



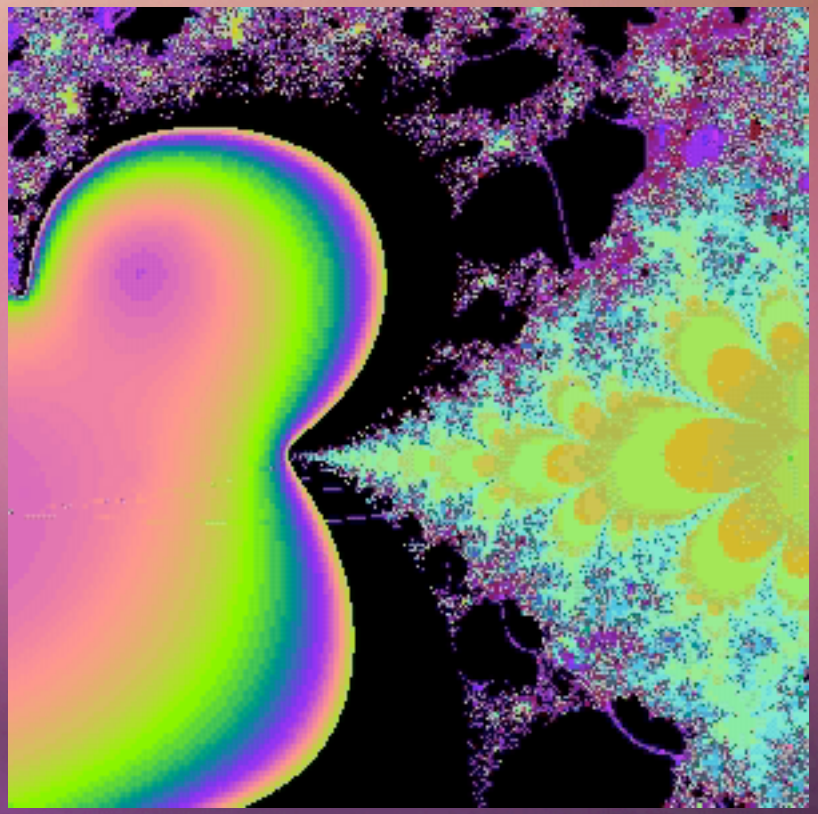
SOUNDS

- Beyond Words
- Hamadulas
- Crystal Bowls
- Sabroso with Udu
- Hang Mix
- Coal Intro

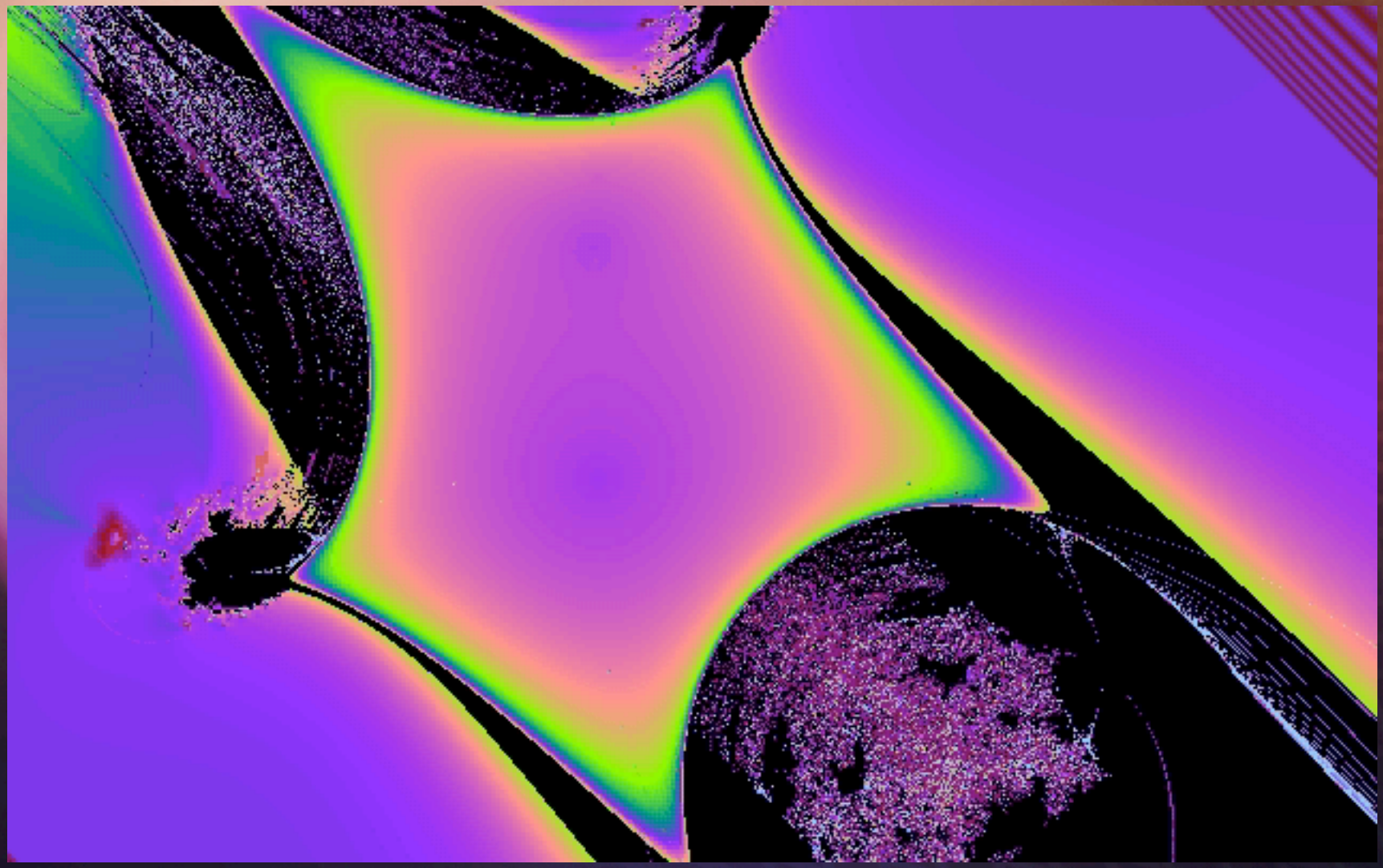
Videos



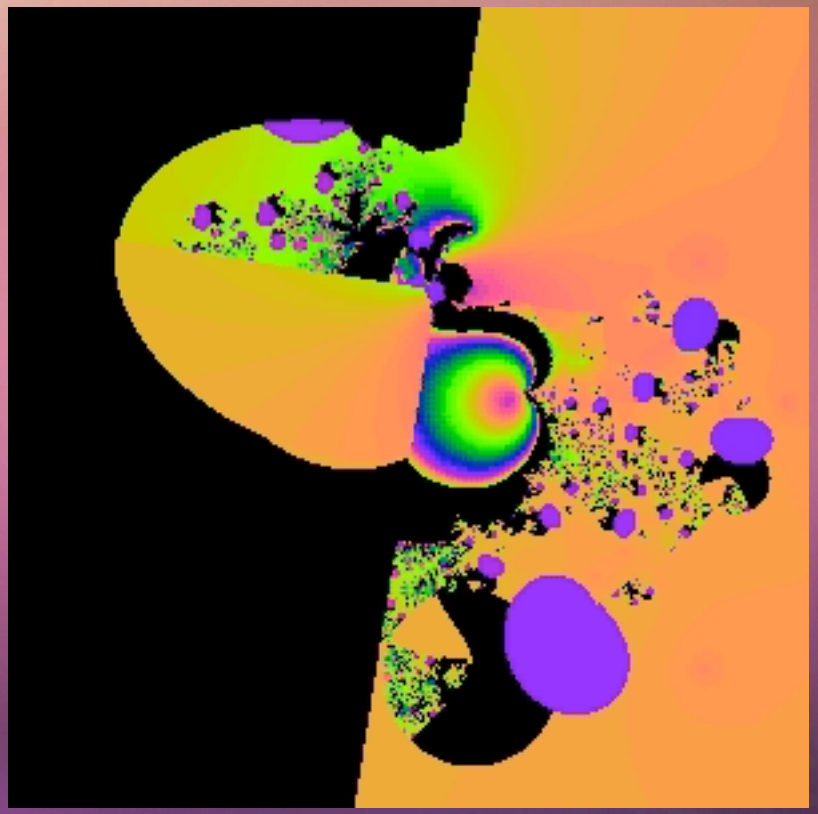
Videos



Videos



Videos

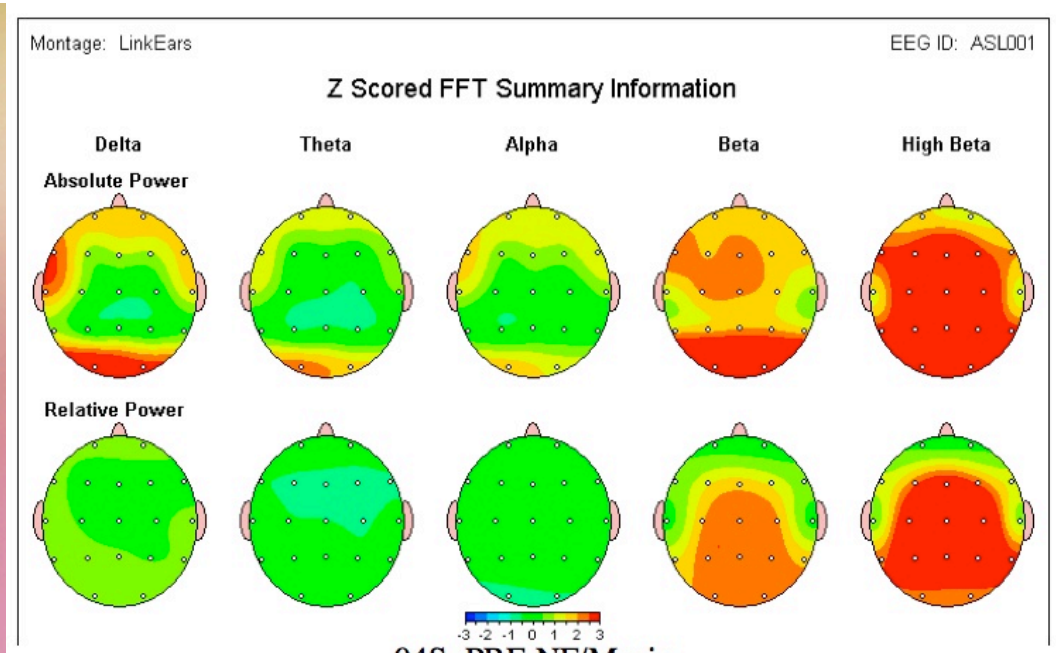


Brain Maps

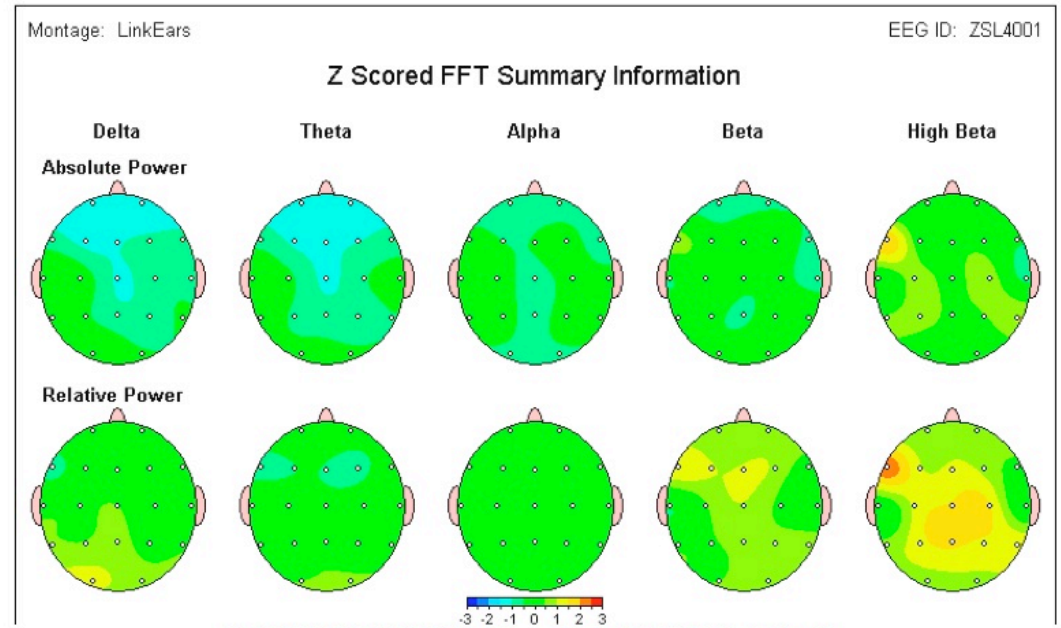
QEEG

PRE-Post

Note a pattern of normalization across all bands, with significant reduction in significantly "hot" Delta, Beta and high Beta rhythms.

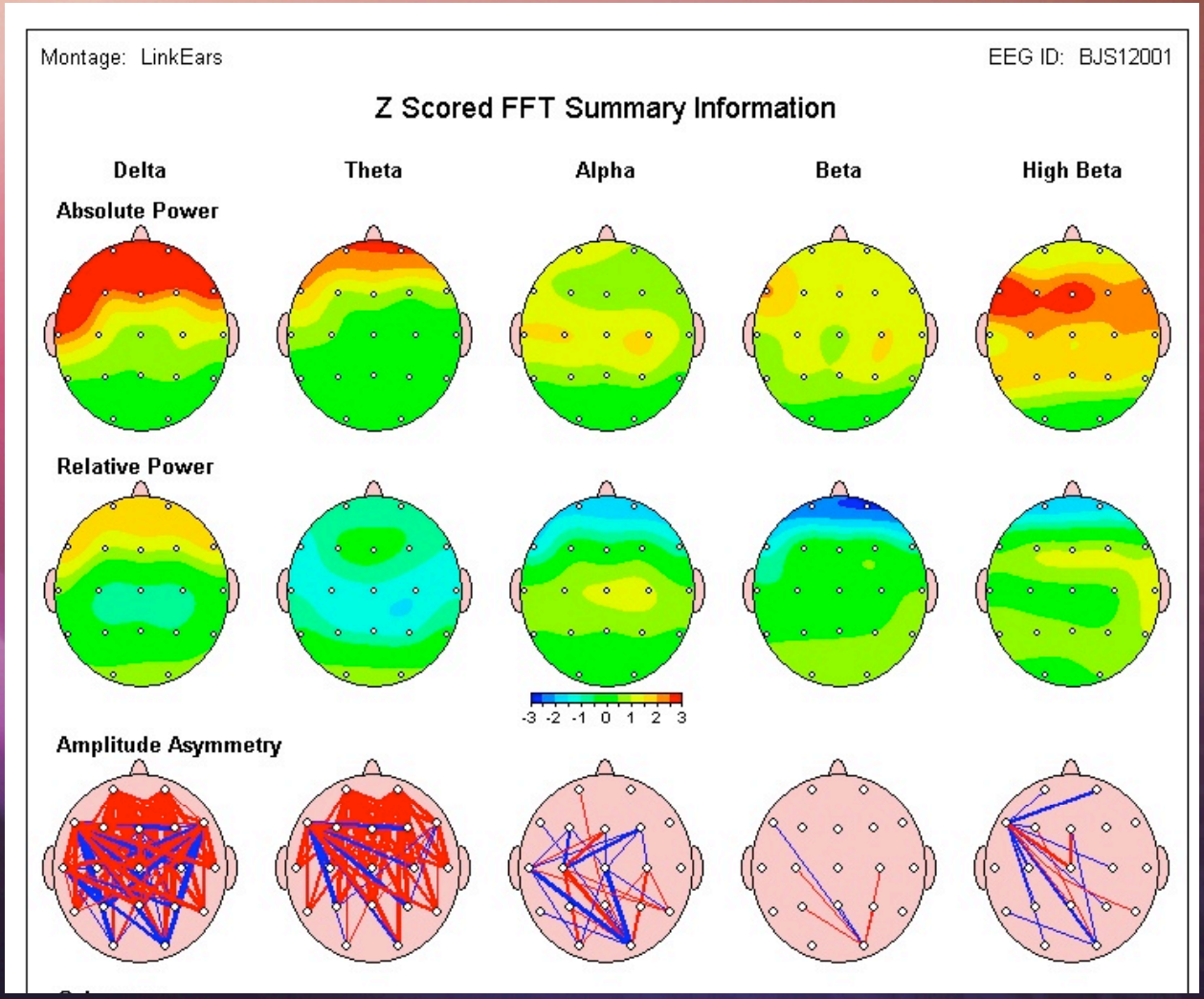


$04S_1$ PRE NF/Music



$04S_1$ POST NF/Music – from 2004 Pilot Study

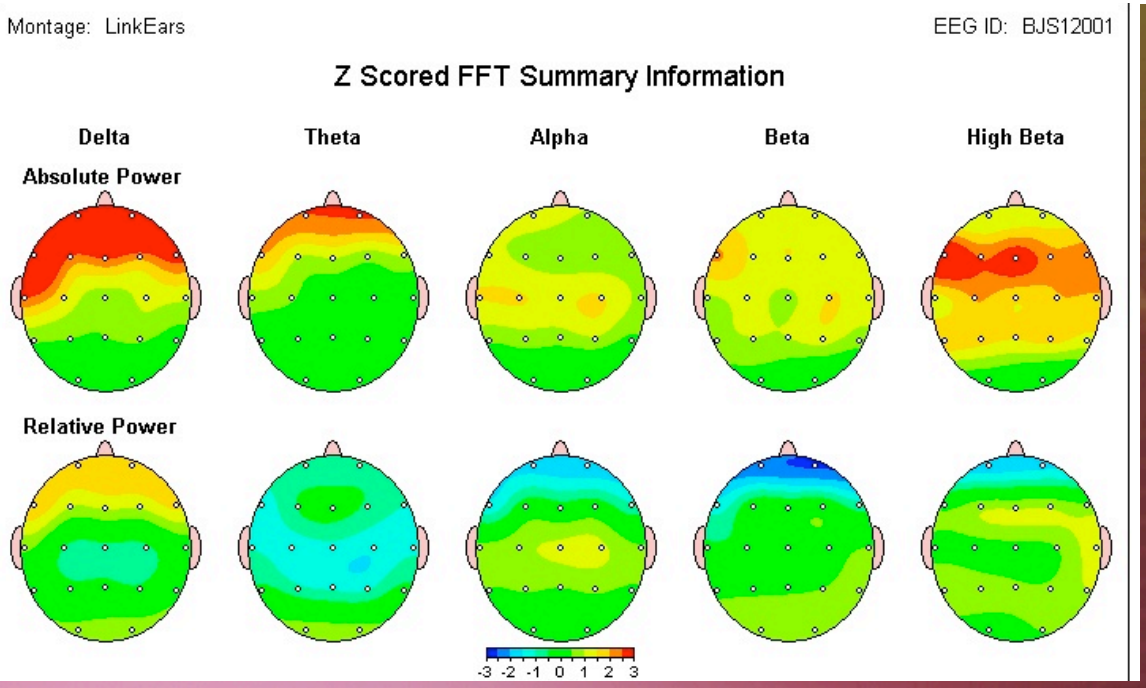
Brain Maps QEEG BASELINE

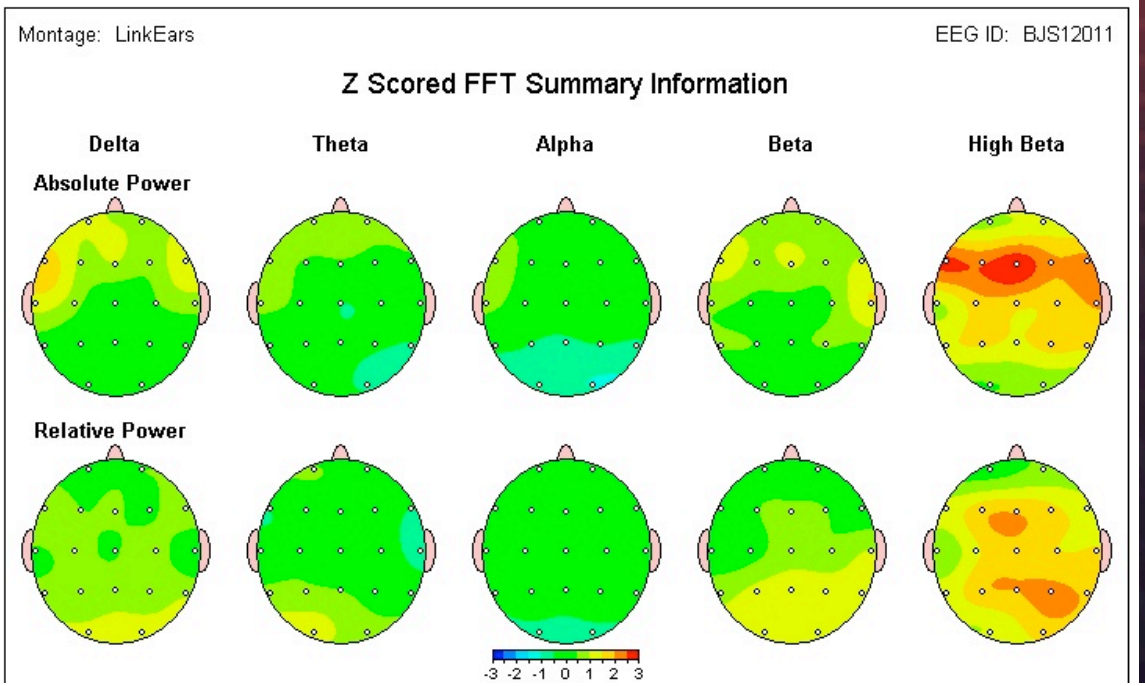


Brain Maps

QEEG
BASELINE
vs.
IMPROV
MUSIC

in a single subject





Brain Maps

QEEG

BASE

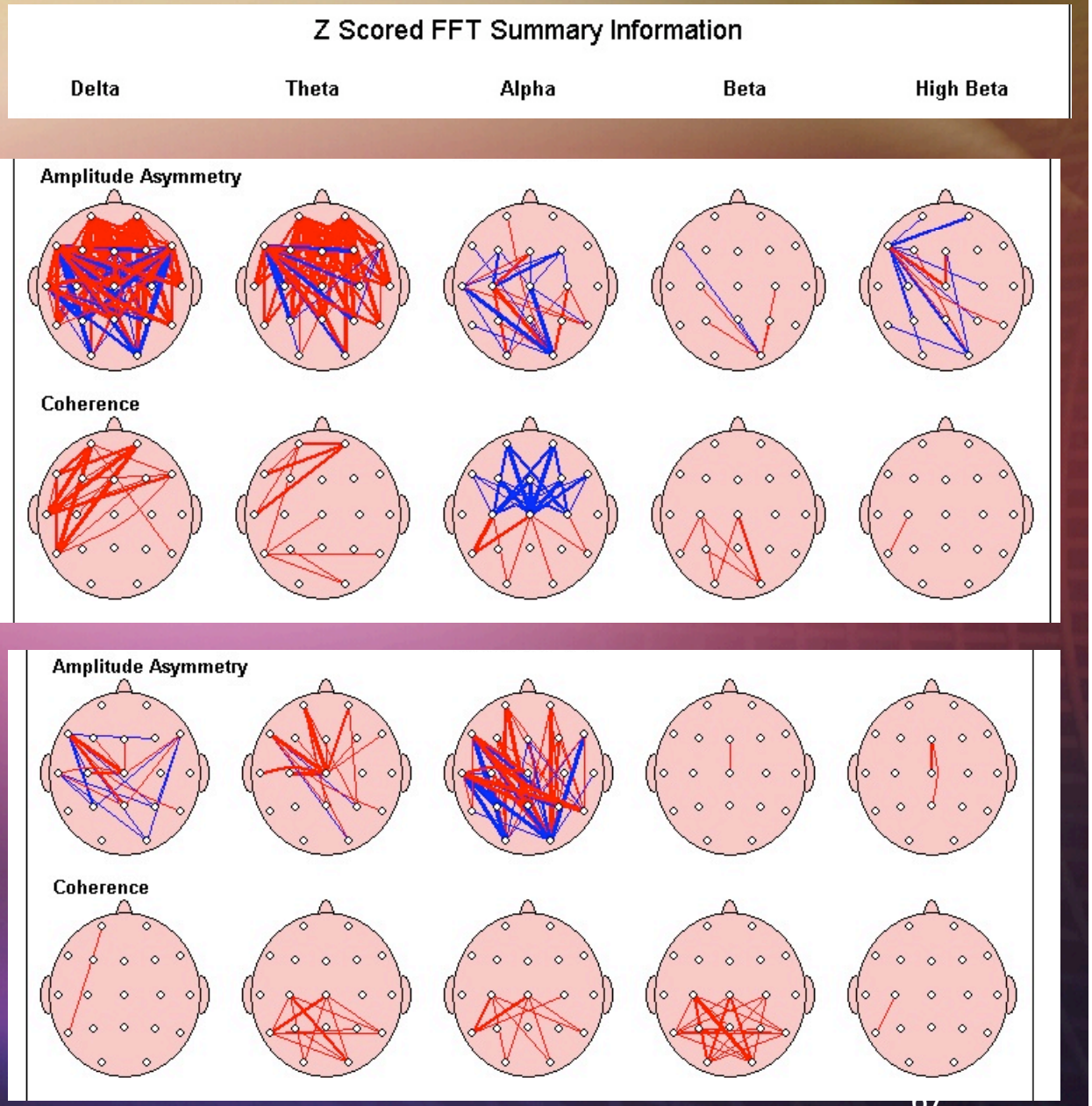
Amplitude

Asymmetry

& Coherence

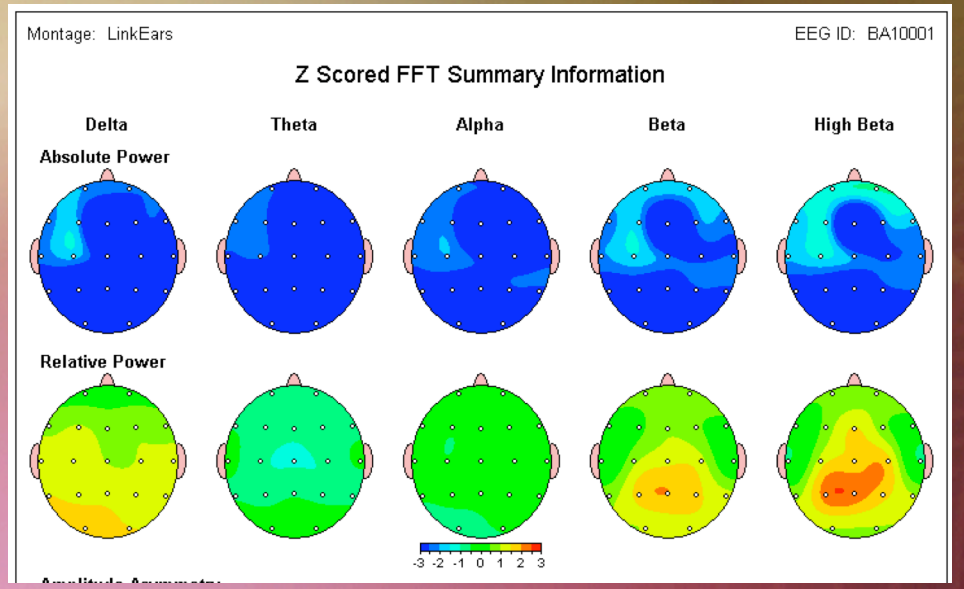
IMPROV

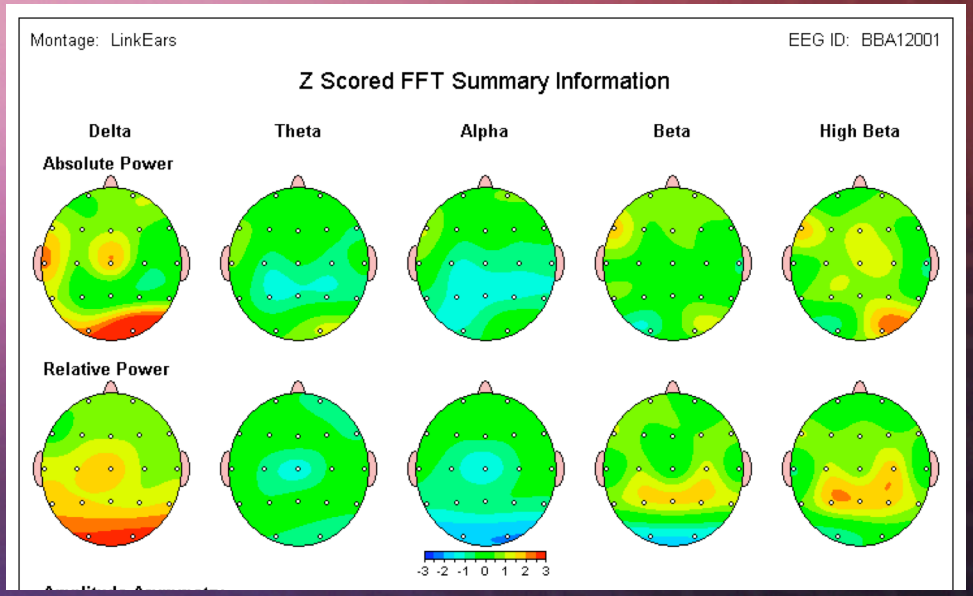
MUSIC



Brain Maps

- This set of pre and post brain-maps shows a shift from low activation (blue) to normal (green) in the 7 year old female CDC subject "B".
- $05B_6$ Pre NF/Music





Discriminant Analysis

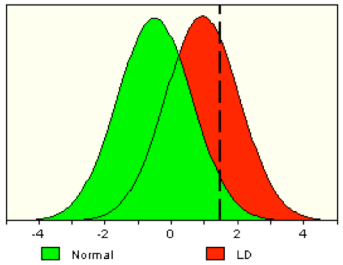
- Note that the probability of inclusion in the LD population has decreased from 99% to 60%.

Montage: LinkEars EEG ID: AJS9001

Learning Disability Discriminant Analysis*

LD DISCRIMINANT SCORE = 1.46 LD PROBABILITY INDEX = 99.0%

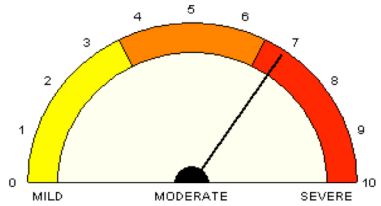
The Learning Disability Probability Index is the subject's probability of membership in the Learning Disability (LD) population.



			RAW	Z
F8	RATIO	T/B	1.05	-0.85
P3	AP	Theta	10.62	-1.28
Cz-C4	AMP	Theta	34.31	-0.35
F7-T6	AMP	Alpha	-110.42	0.28
T5-O2	COH	Theta	32.85	0.97
F3-Fz	COH	Alpha	81.00	-0.15
FP1-T5	PHA	Beta	21.38	
T4-T6	PHA	Delta	6.75	-0.03
F8-T3	PHA	Delta	-30.37	
T4-Pz	PHA	Theta	7.10	-0.01
FP1-Pz	PHA	Delta	75.18	
F8-Pz	PHA	Beta	20.93	
C3-O2	PHA	Alpha	-6.87	
FP1-F4	PHA	Alpha	-16.64	

LD SEVERITY INDEX = 6.89

This severity score places the patient in the SEVERE range of severity.



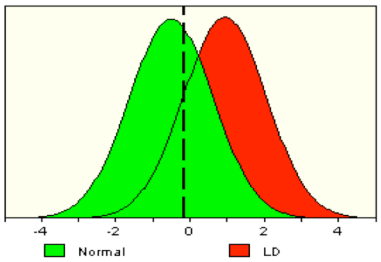
The LD Severity Index is an estimate of the neurological severity of Learning Disability.

Montage: LinkEars EEG ID: BJS12001

Learning Disability Discriminant Analysis*

LD DISCRIMINANT SCORE = -0.18 LD PROBABILITY INDEX = 60.0%

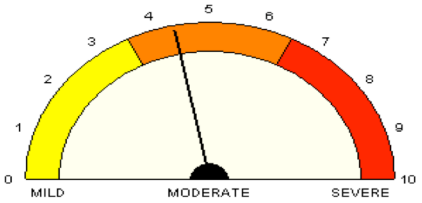
The Learning Disability Probability Index is the subject's probability of membership in the Learning Disability (LD) population.



			RAW	Z
F8	RATIO	T/B	0.93	-1.11
P3	AP	Theta	18.22	-0.48
Cz-C4	AMP	Theta	16.24	0.42
F7-T6	AMP	Alpha	-75.70	1.19
T5-O2	COH	Theta	49.18	1.81
F3-Fz	COH	Alpha	64.88	-0.96
FP1-T5	PHA	Beta	-13.53	
T4-T6	PHA	Delta	6.51	-0.07
F8-T3	PHA	Delta	26.68	
T4-Pz	PHA	Theta	14.71	
FP1-Pz	PHA	Delta	-11.35	
F8-Pz	PHA	Beta	-32.30	
C3-O2	PHA	Alpha	3.78	
FP1-F4	PHA	Alpha	0.69	0.31

LD SEVERITY INDEX = 4.36

This severity score places the patient in the MODERATE range of severity.



The LD Severity Index is an estimate of the neurological severity of Learning Disability.

Pre vs. Post-Intervention

Discriminant Analysis

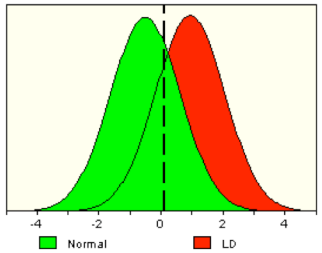
- Also, it is interesting to note that 1J's LD index pre-intervention was only 65% during the condition while listening to Vivaldi and 60% while listening to "slow" music.

Montage: LinkEars EEG ID: AJS9007

Learning Disability Discriminant Analysis*

LD DISCRIMINANT SCORE = 0.06 LD PROBABILITY INDEX = 65.0%

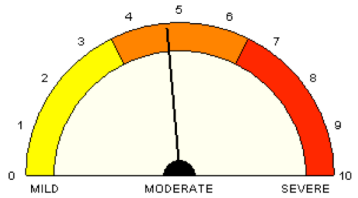
The Learning Disability Probability Index is the subject's probability of membership in the Learning Disability (LD) population.



			RAW	Z
F8	RATIO	T/B	1.05	-0.87
P3	AP	Theta	13.53	-0.91
Cz-C4	AMP	Theta	29.35	-0.14
F7-T6	AMP	Alpha	-118.52	0.07
T5-O2	COH	Theta	39.89	1.35
F3-Fz	COH	Alpha	84.30	0.00
FP1-T5	PHA	Beta	10.37	
T4-T6	PHA	Delta	22.17	
F8-T3	PHA	Delta	3.61	
T4-Pz	PHA	Theta	0.23	-0.76
FP1-Pz	PHA	Delta	-7.06	
F8-Pz	PHA	Beta	77.97	
C3-O2	PHA	Alpha	-11.22	
FP1-F4	PHA	Alpha	-2.24	

LD SEVERITY INDEX = 4.72

This severity score places the patient in the MODERATE range of severity.



The LD Severity Index is an estimate of the neurological severity of Learning Disability.

Discriminant Analysis

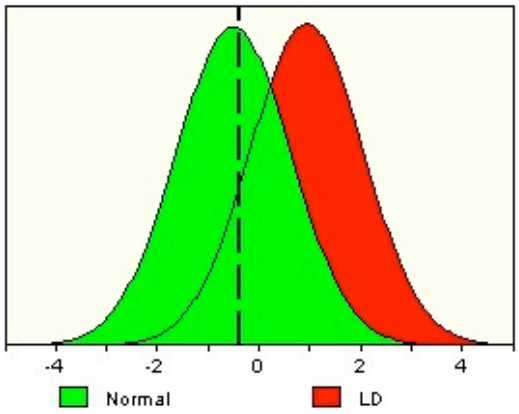
- During IMPROV music (playing) LD probability drops to “not significant” at Post-Intervention.

Montage: LinkEars EEG ID: BJS12011

Learning Disability Discriminant Analysis*

LD DISCRIMINANT SCORE = -0.43 LD PROBABILITY INDEX = Not Significant

The Learning Disability Probability Index is the subject's probability of membership in the Learning Disability (LD) population.



			RAW	Z
F8	RATIO	T/B	1.26	-0.53
P3	AP	Theta	23.93	-0.08
Cz-C4	AMP	Theta	4.99	0.90
F7-T6	AMP	Alpha	1.82	3.21
T5-O2	COH	Theta	61.52	2.35
F3-Fz	COH	Alpha	80.57	-0.17
FP1-T5	PHA	Beta	-17.48	
T4-T6	PHA	Delta	8.44	0.19
F8-T3	PHA	Delta	-7.55	
T4-Pz	PHA	Theta	16.47	
FP1-Pz	PHA	Delta	-5.25	
F8-Pz	PHA	Beta	14.24	
C3-O2	PHA	Alpha	13.59	0.06
FP1-F4	PHA	Alpha	6.76	0.83

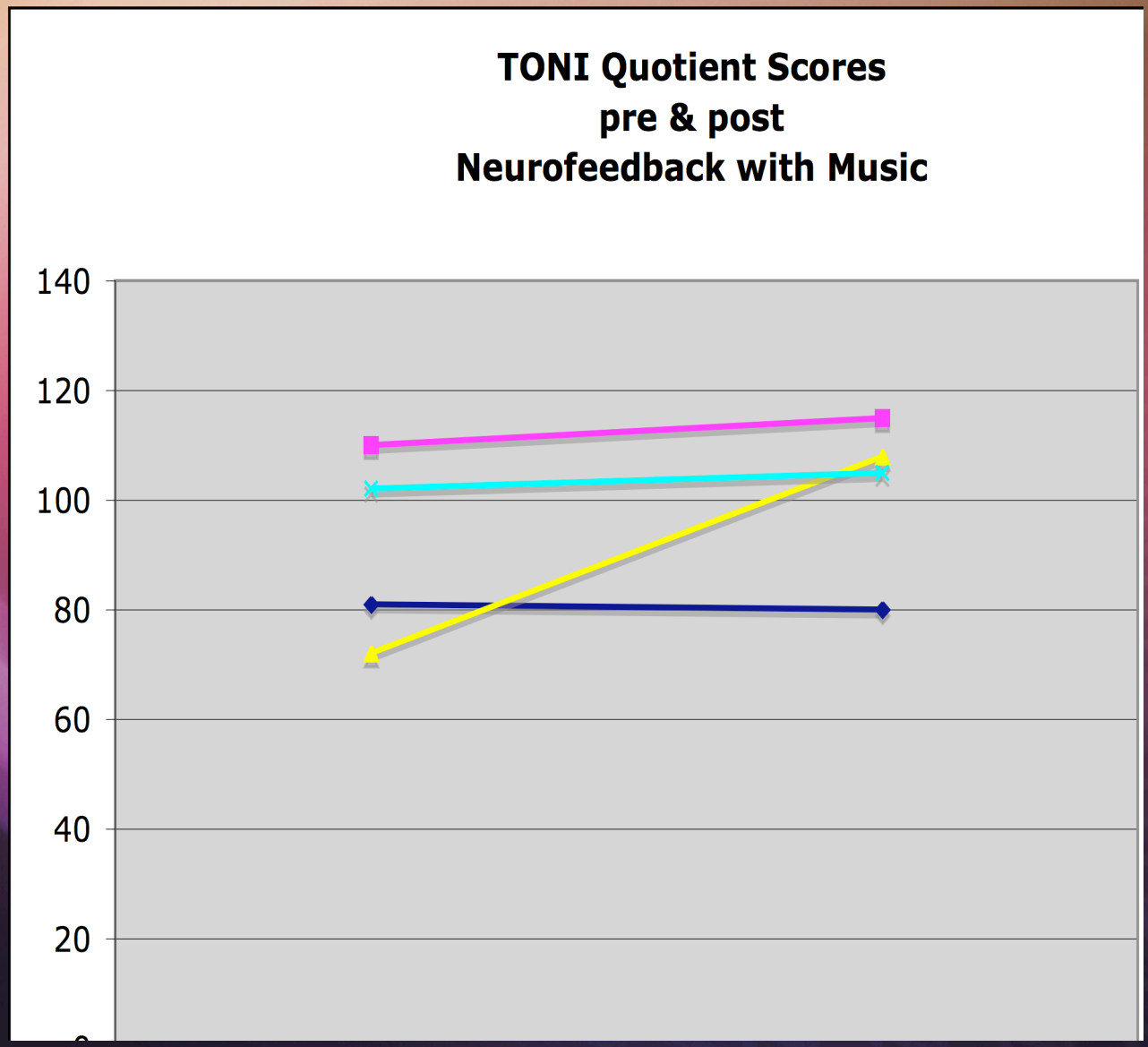
TONI-3 Results NF-MUS group

TONI-3 Results

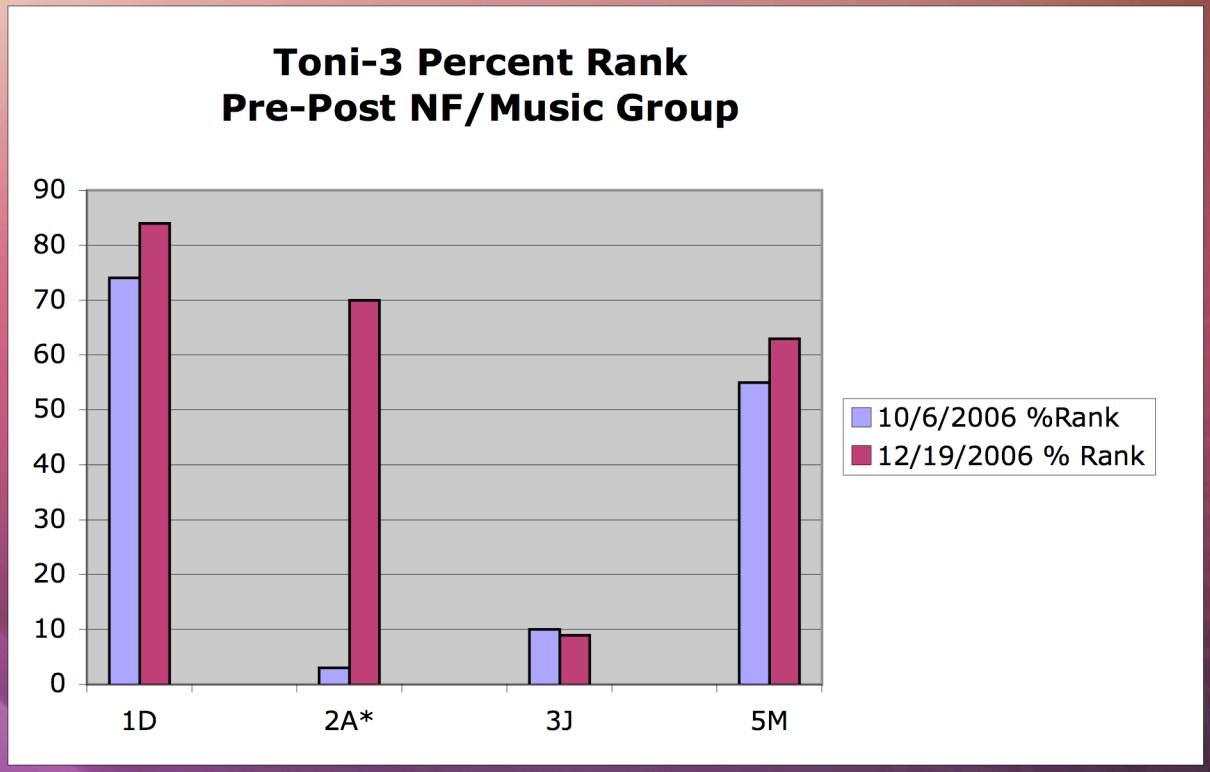
			Percentages				
Name	**Date**	**Raw**	**Quotient**	**Rank**	**D.Q.**	**Descrip.**	**SEM**
1D	6-Oct	24	110	74	90-110	Average	5
	19-Dec	26	115	84	111-120	Above Avg.	5
2A*	6-Oct	6	72	3	70-79	Poor	5
	19-Dec	24	108	70	90-110	Average	5
3J	6-Oct	14	81	10	80-89	Below Avg.	4
	19-Dec	13	80	9	80-89	Below Avg.	4
5M	6-Oct	21	102	55	90-110	Average	5
	19-Dec	23	105	63	90-110	Average	5

All TONI-3 scores are at the 95% level of confidence +/-* 2SEM
*Statistically significant change in score

TONI-3 Results NF-MUS group

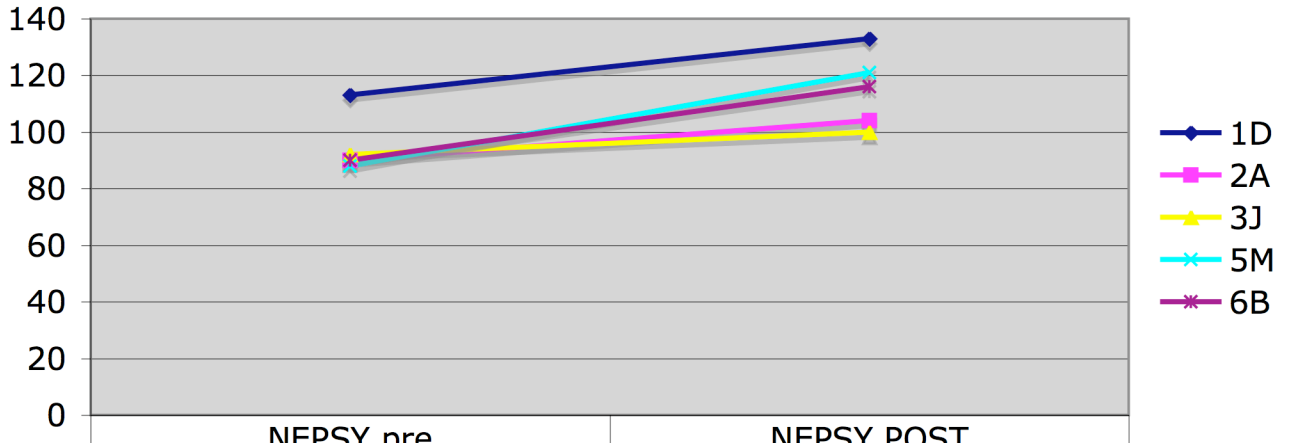


TONI-3 Results NF-MUS group



NEPSY Results NF-MUS group

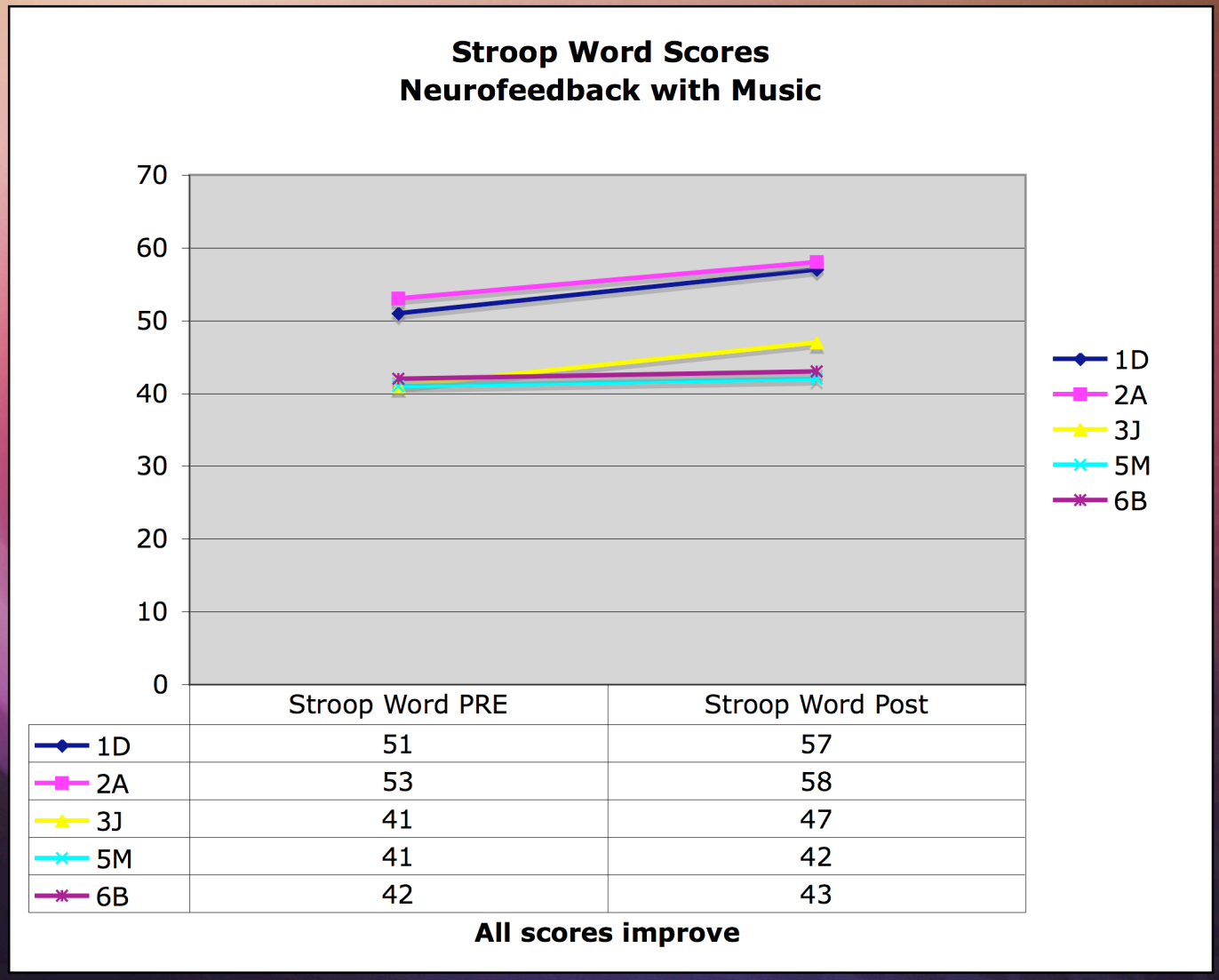
NEPSY Attention/Executive function
Core Domain Scores



	NEPSY pre	NEPSY POST
1D	113	133
2A	90	104
3J	92	100
5M	88	121
6B	90	116

All scores improve
Following Neurofeedback + MUS

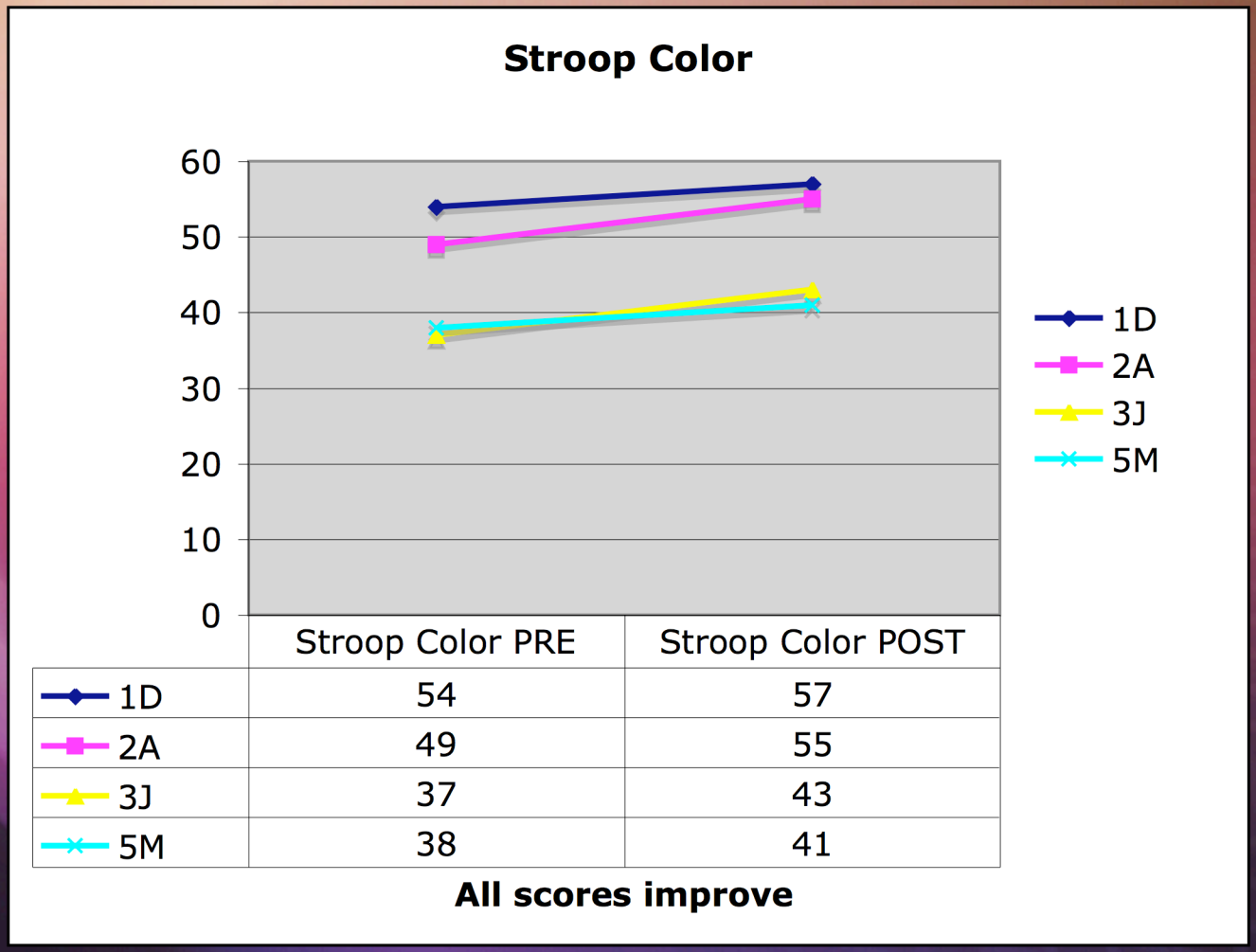
STROOP Results NF-MUS group



	Stroop Word PRE	Stroop Word Post
1D	51	57
2A	53	58
3J	41	47
5M	41	42
6B	42	43

All scores improve

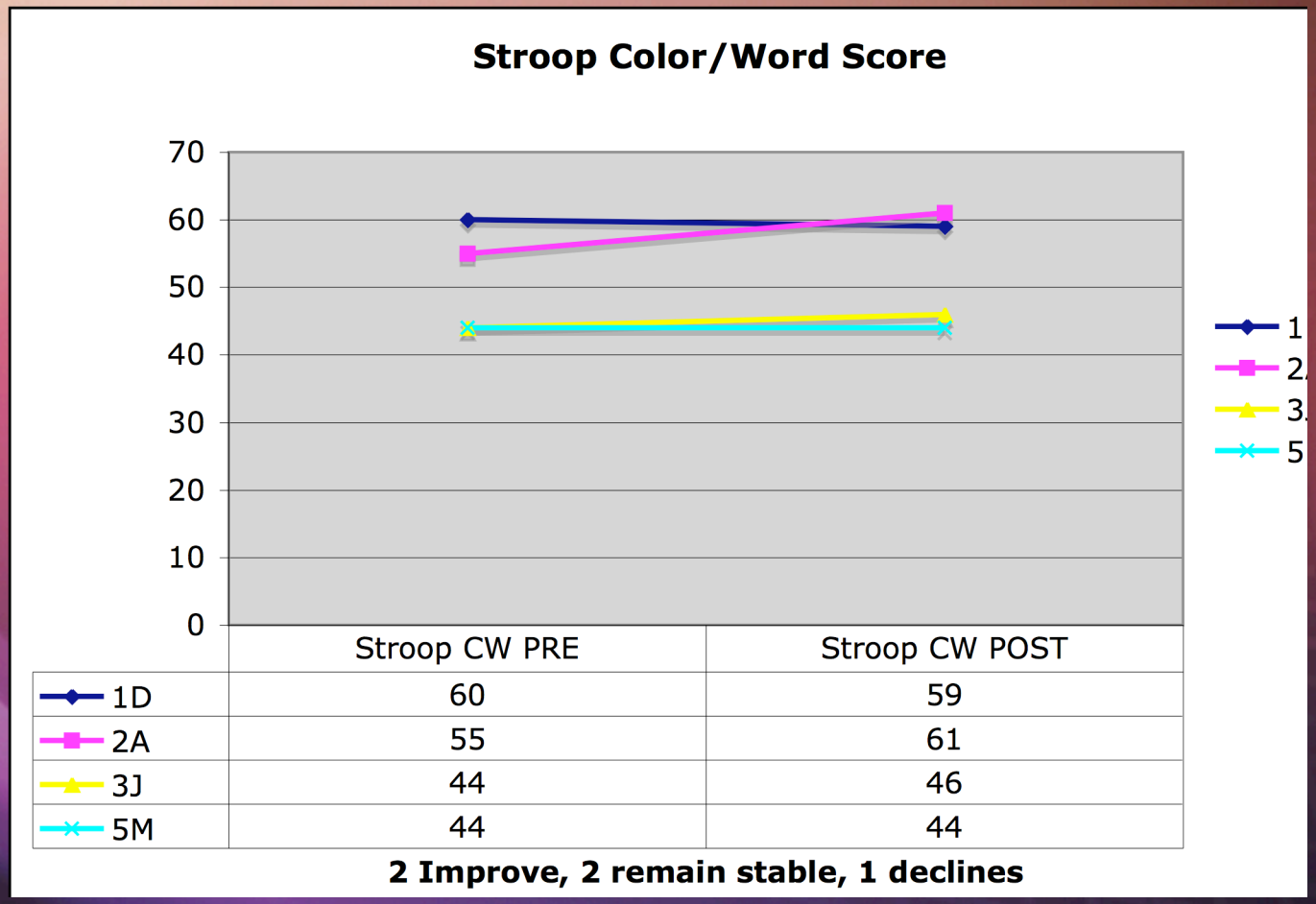
STROOP Results NF-MUS group



	Stroop Color PRE	Stroop Color POST
1D	54	57
2A	49	55
3J	37	43
5M	38	41

All scores improve

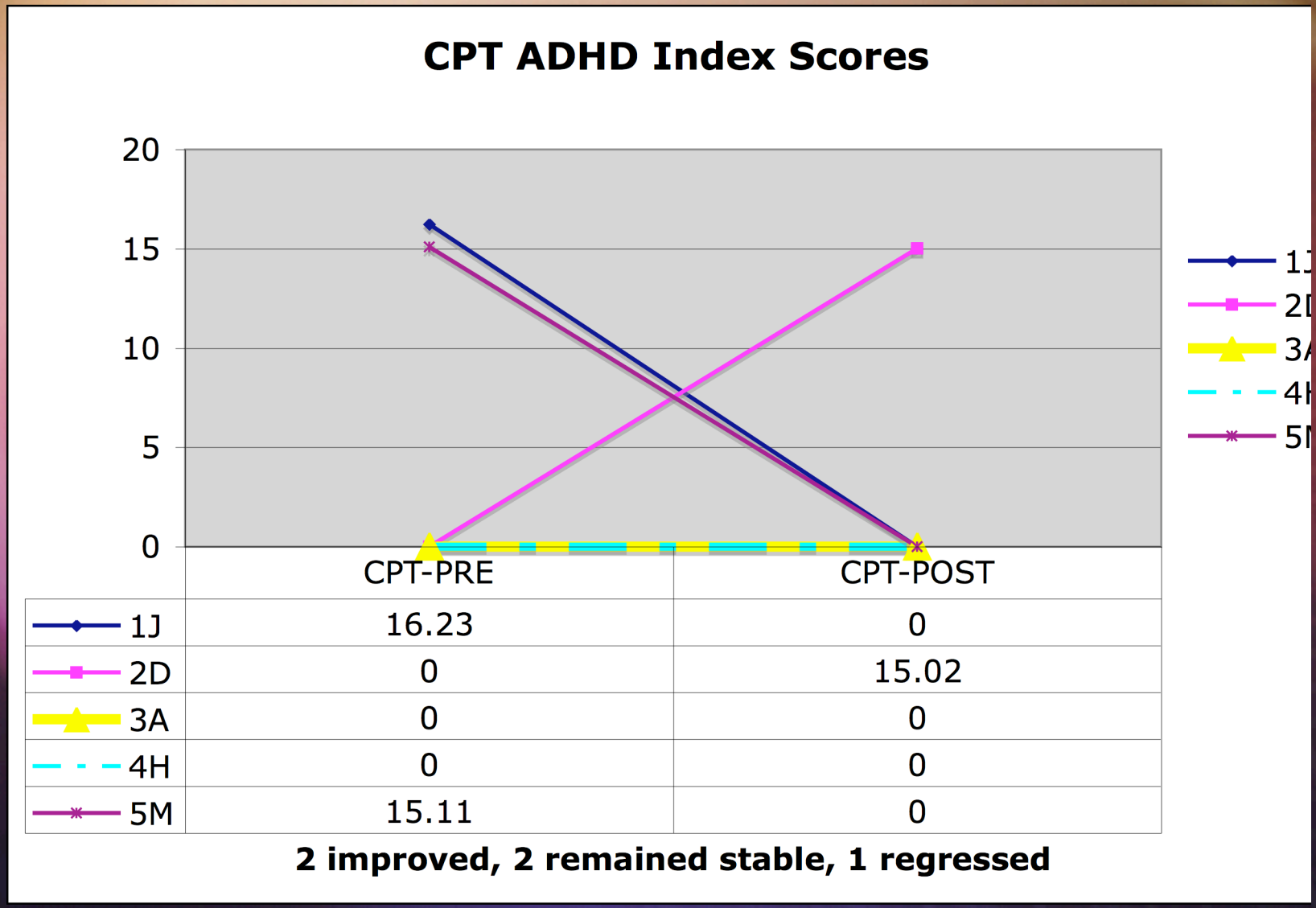
STROOP Results NF-MUS group



	Stroop CW PRE	Stroop CW POST
1D	60	59
2A	55	61
3J	44	46
5M	44	44

2 Improve, 2 remain stable, 1 declines

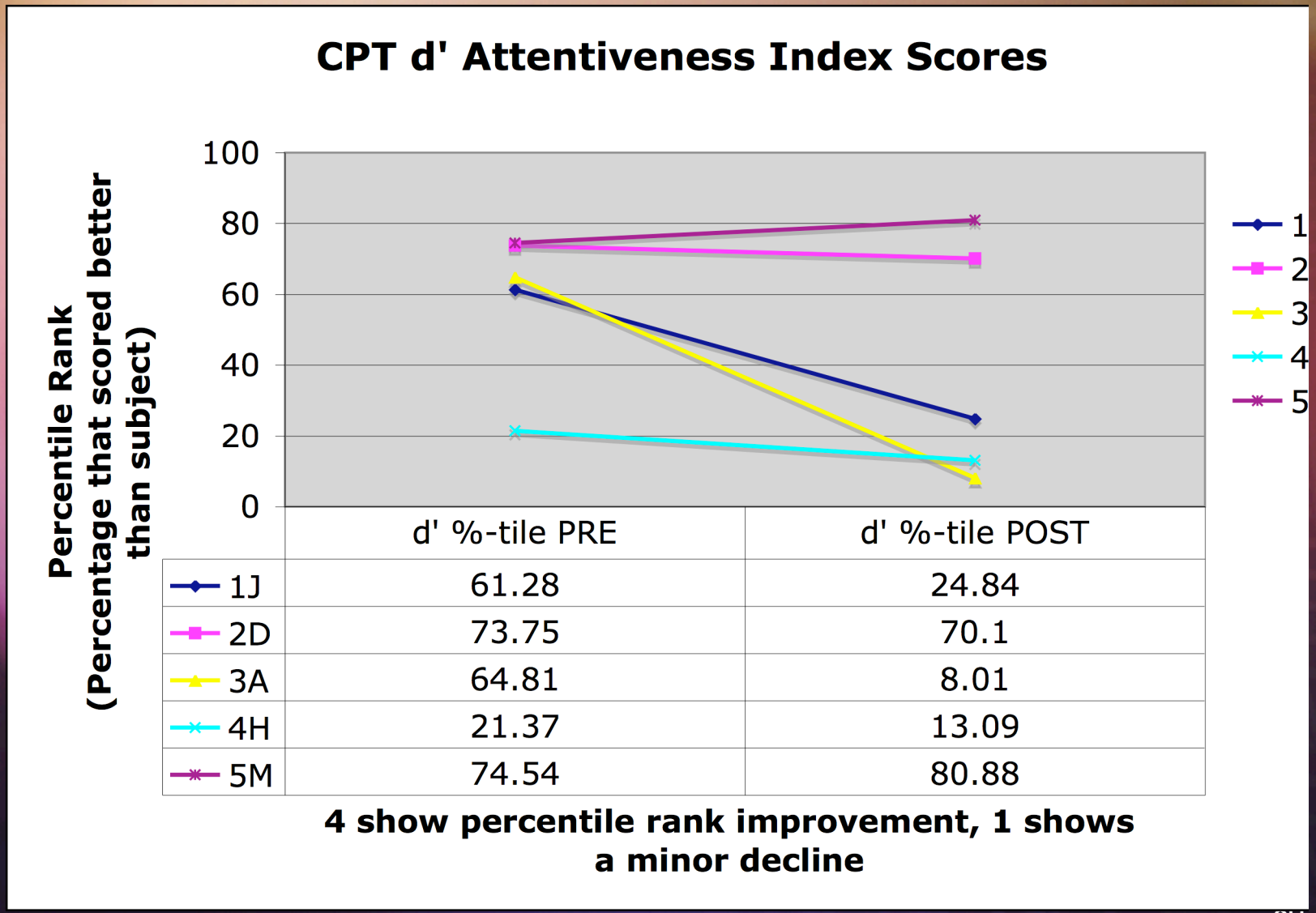
CPT Results NF-MUS group



	CPT-PRE	CPT-POST
1J	16.23	0
2D	0	15.02
3A	0	0
4H	0	0
5M	15.11	0

2 improved, 2 remained stable, 1 regressed

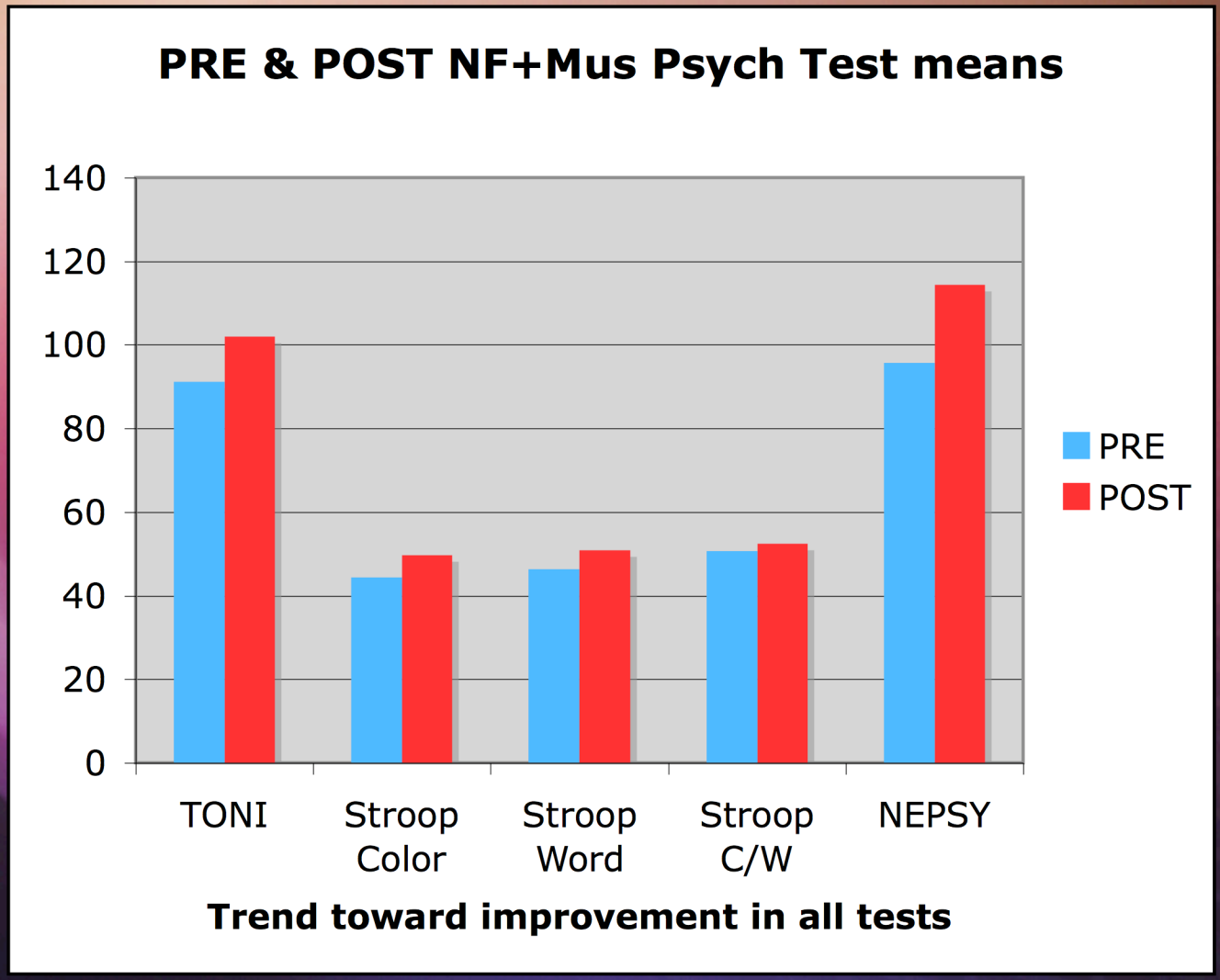
CPT Results NF-MUS group



	d' %-tile PRE	d' %-tile POST
1J	61.28	24.84
2D	73.75	70.1
3A	64.81	8.01
4H	21.37	13.09
5M	74.54	80.88

4 show percentile rank improvement, 1 shows a minor decline

Trend toward improvement



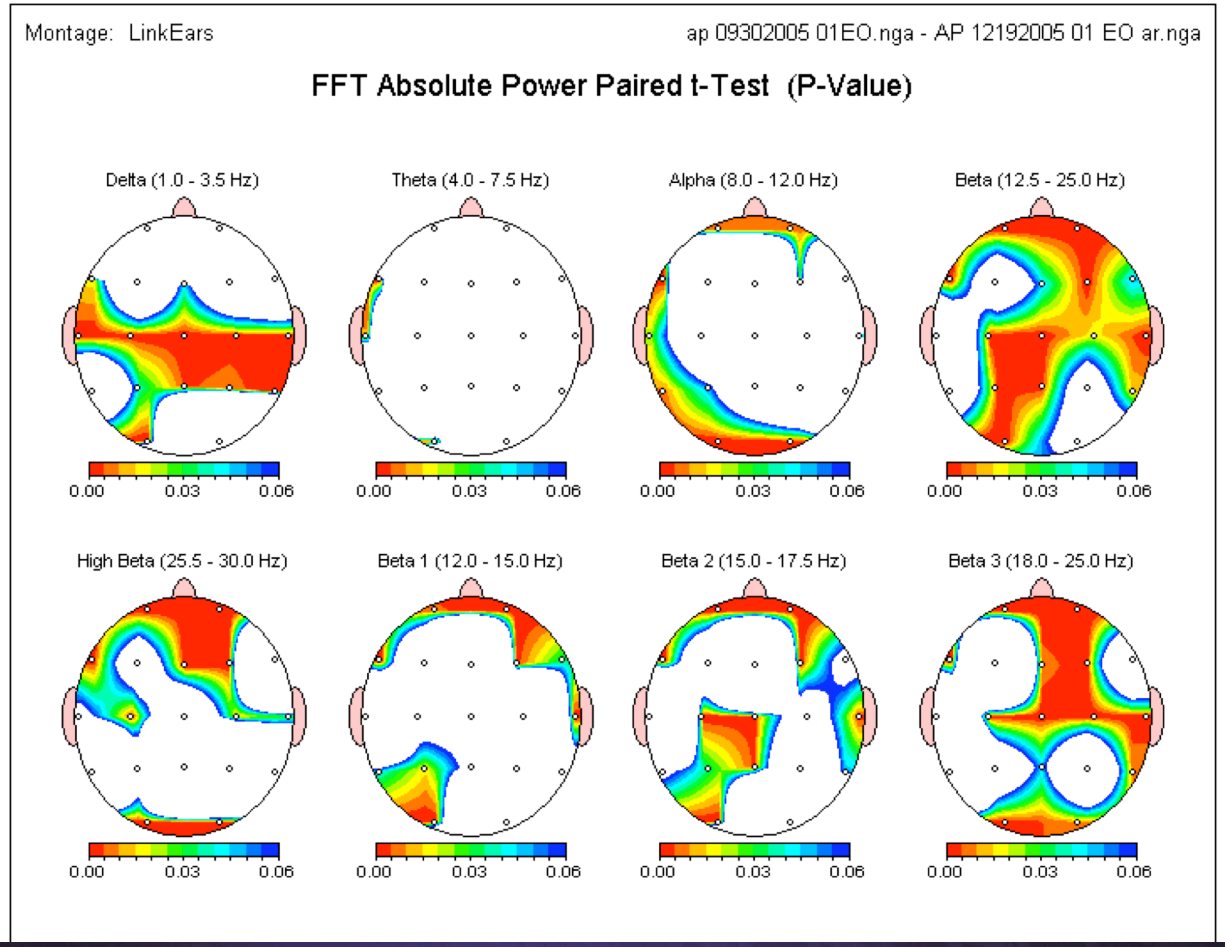
Between Group Differences

Control vs. 3 NF Groups

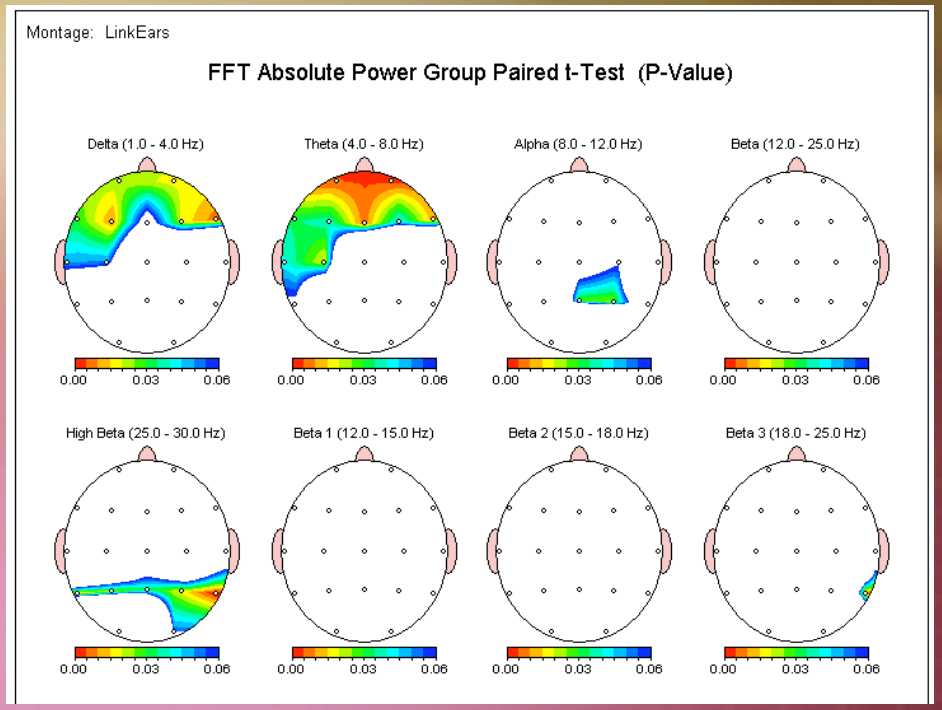
Between Group Differences

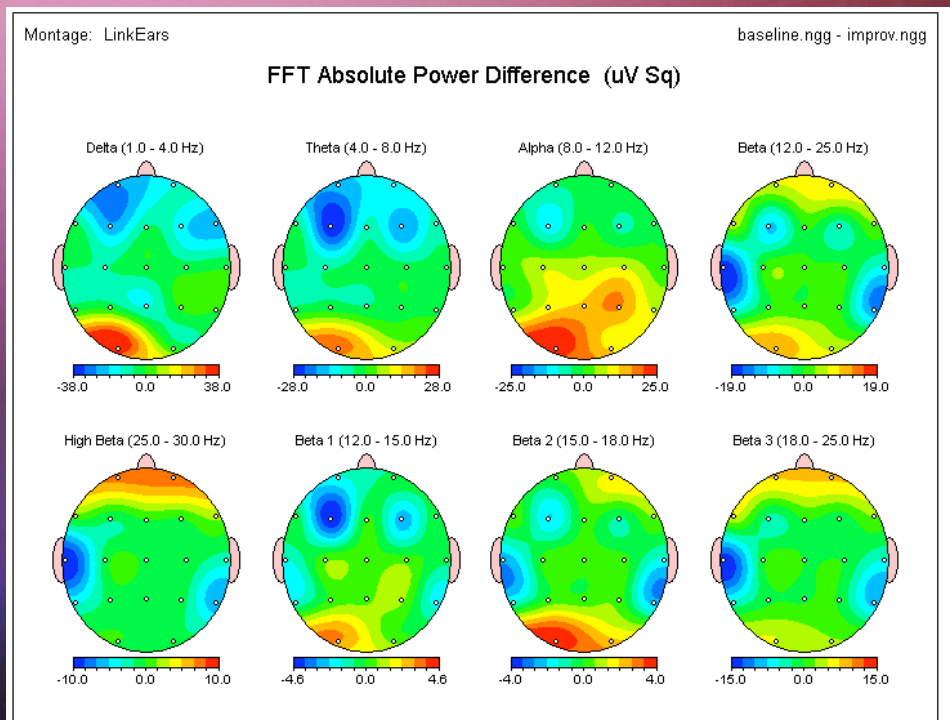
Condition	0- Control	1- NF1	2- NF2	3- NF+MUS		
Dependent Variable						
CONPOPP 1	60.67	72.42	68.67	62.75		
CONPOPP 2	62.78	70.75	66.08	54	F Value	0.71
					P Value	0.55
CONPCOG 1	66.63	64.42	56.42	67		
CONPCOG 2	65.78	59.42	59.25	52.5	F Value	**3.05**
					P Value	**0.04**
CONPHYP 1	73.78	77.92	72.42	68		
CONPHYP 2	73.67	71.33	68.25	47.25	F Value	**2.46**
					P Value	**0.08**
CONPADD 1	68.67	68.75	62.17	70.5		
CONPADD 2	67.67	66	64	52.5	F Value	**4.03**
					P Value	**0.02**
NEPAUD 1	8.22	8.67	7.75	11.8		
NEPAUD 2	7.89	8.42	8.17	13.75	F Value	**4.4**
					P Value	**0.01**
NEPVIS 1	6.78	9.82	9.55	6.8		
NEPVIS 2	7.67	10.92	11.08	12.25	F Value	**2.7**
					P Value	**0.06**

PRE-POST T-TEST

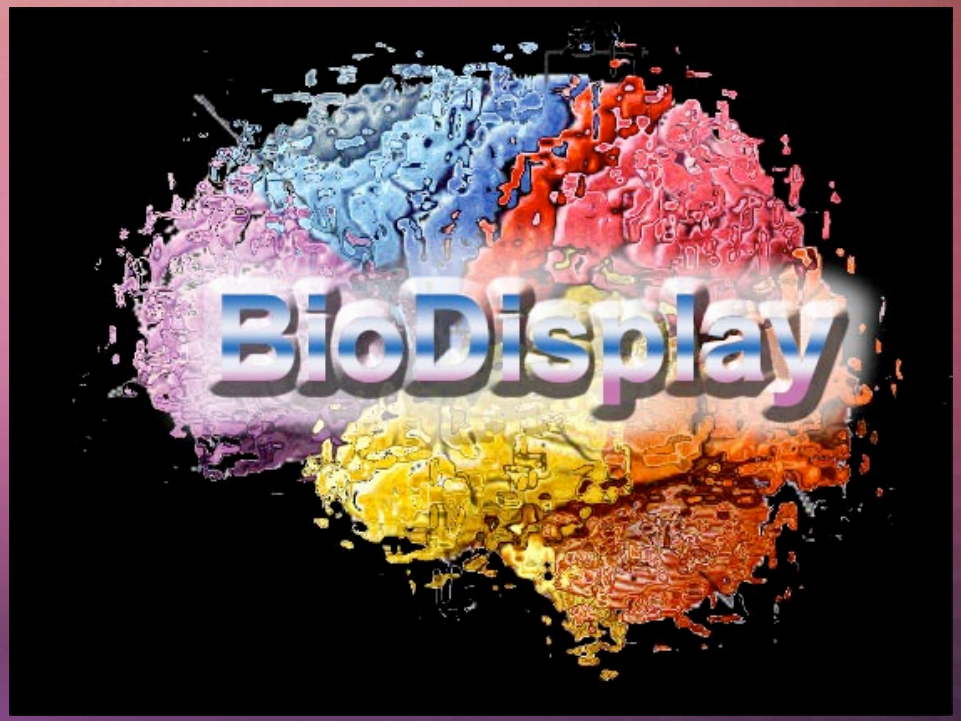


All subjects Baseline vs. Improv

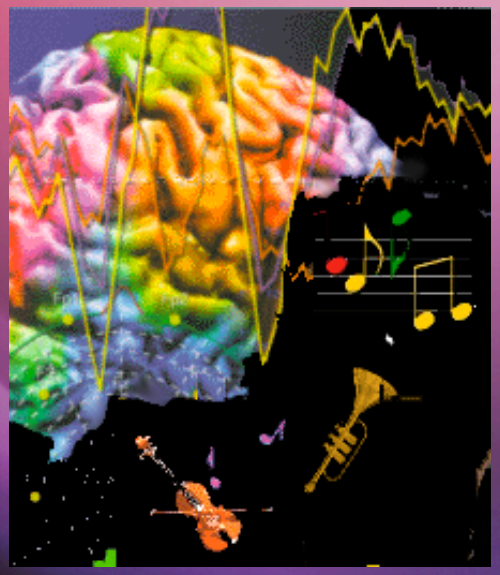




Future direction: Brain-computer interfaces



Helping ADHD Children with Music Therapy & EEG Neurofeedback: Brain-jamming for focus



Eric B. Miller

The Biofeedback Network

www.Biofeedback.net