Treating Anxiety & Depression With Neurofeedback

Richard Soutar, Ph.D. BCN

To Summarize

“Activity in the left anterior regions of the brain reflects trait-like tendencies to experience and express approach-related emotions such as happiness and anger, whereas activity in the right anterior regions of the brain reflects withdrawal-related emotions such as fear (Davidson, 1992; Davidson et al., 1990; Davidson & Fox; 1982, 1989; Fox & Davidson, 1987; Gable & Harmon-Jones, 2008; Miskovic & Schmidt, 2010). “

Solomon et al, 2014

General Findings

- Anxiety increases with excessive right hemisphere activation- anterior and posterior.
- Increases in beta wave activity with decreases in alpha wave activity.
- Depression increases with left hemisphere de-activation.
- Decreases in beta wave activity with increases in alpha wave activity.

Neurphysiological Underpinnings

- Ascending visceral pathways
- Cortical pathways
- Subcortical and brainstem contributions
- Dynamic Network Mechanisms

Ascending Pathways

Sympathetic/Parasympathetic Opponent Process

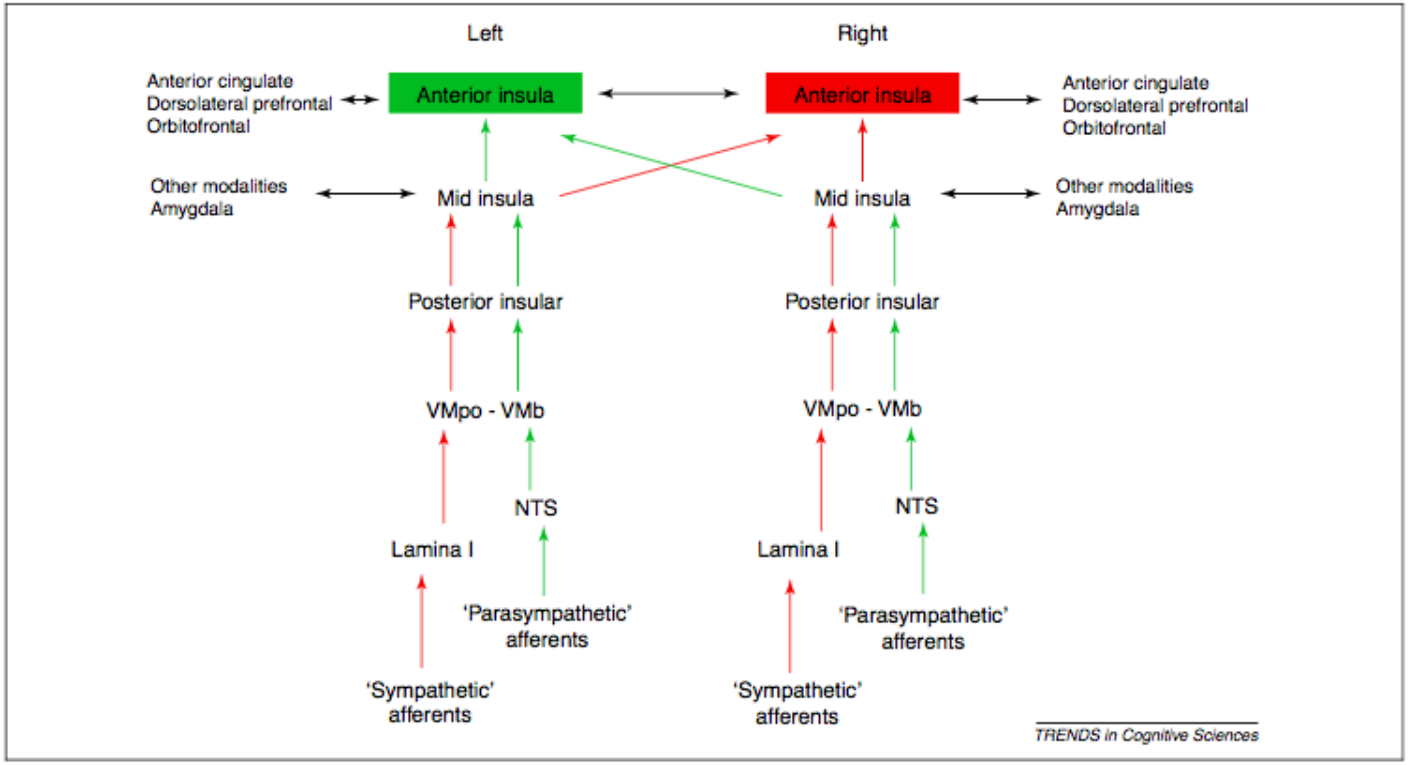
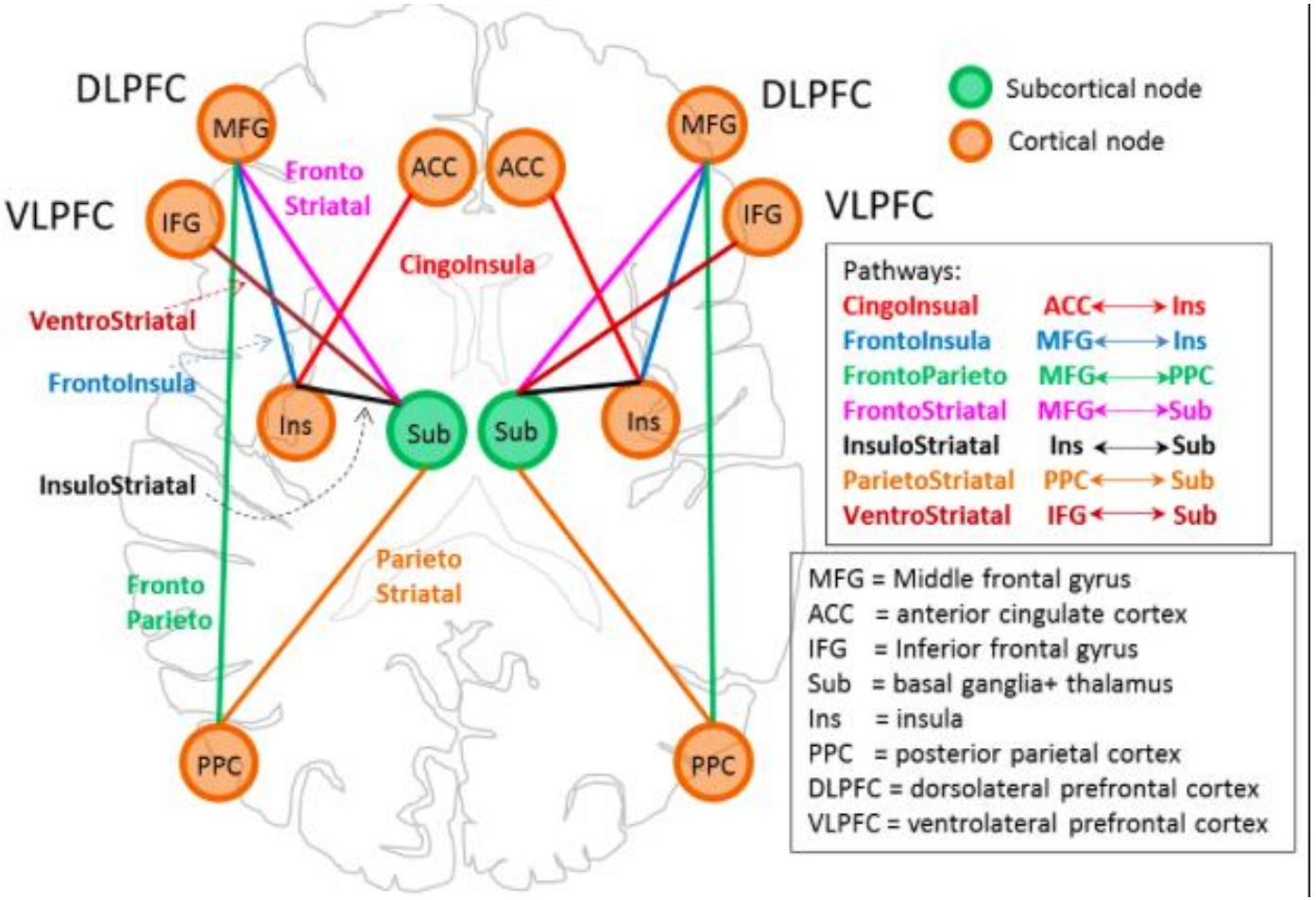


Figure 1. A schematic diagram indicating the ascending pathways of the homeostatic afferents that parallel the sympathetic and parasympathetic halves of the autonomic nervous system and how they become asymmetrically lateralized in the left and right forebrain of humans.

Activating the Left Pathway Begins to Deactivate the Right Pathway

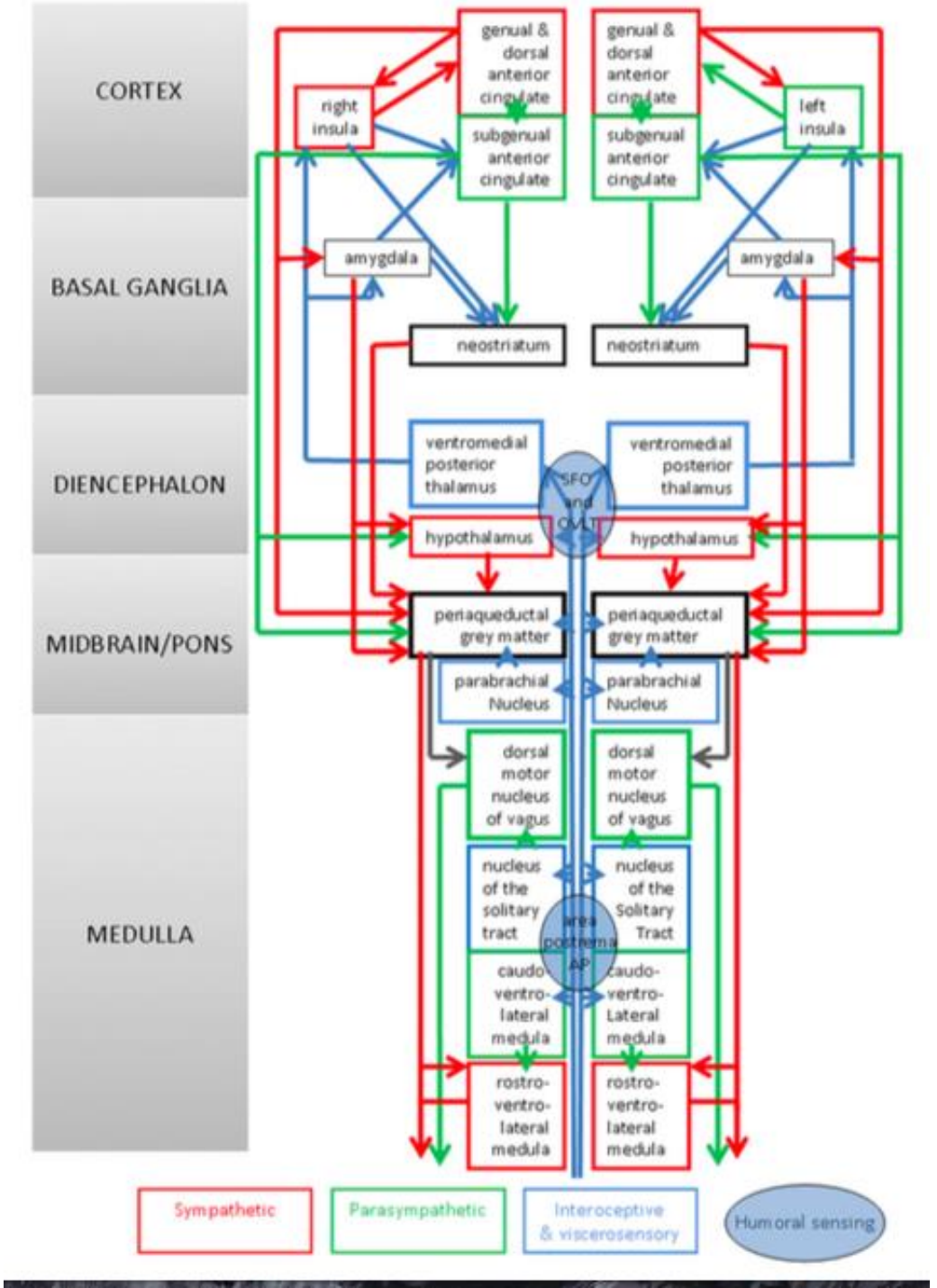
Vagus vs Splanchnic Pathway

Left & Right Neural Pathways



Guo et al, 20?

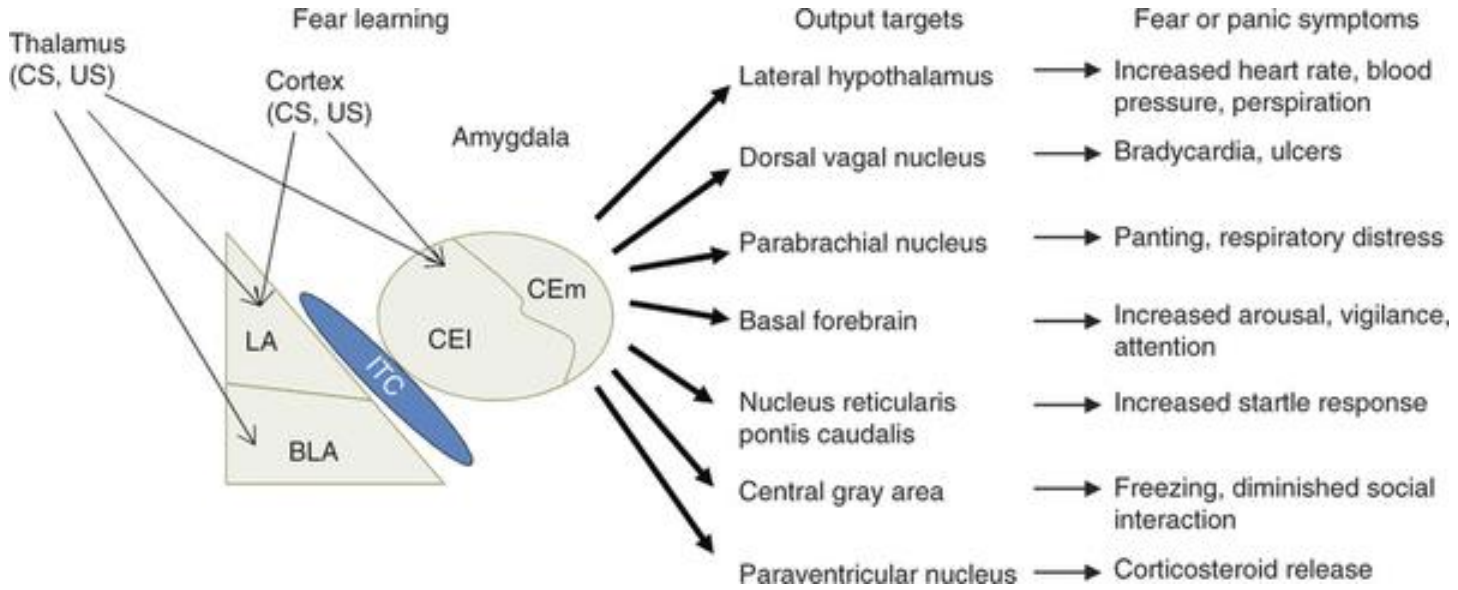
Subcortical Pathways



The Amygdala & The CNS

- The amygdala has direct control over hypothalamic, somatic, endocrine and brain stem functions.
- It indirectly precipitates immune system suppression through glucocortical levels.

Extensive trauma can generate periodic recurrent paroxysmal activity in the amygdala.
It is an important survival mechanism



Switching System Dominance

Salience Network Theory & Dynamics

- Bottom–up detection of salient events
- Switching between other large-scale networks to facilitate access to attention and working memory resources when a salient event is detected
- Interaction of the anterior and posterior insula to modulate autonomic reactivity to salient stimuli
- Strong functional coupling with the anterior cingulate cortex that facilitates rapid access to the motor system.

In this manner, with the insula as its integral hub, the salience network assists target brain regions in the generation of appropriate behavioral responses to salient stimuli.

Salience Network Allostatsis
Energy Conservation & Balance

Left Hemisphere Activation
Increases Energy

Increases Oxytocin
Approach Behaviors
Increases Dopamine
Compassion
Joy
Romance

Right Hemisphere Activation
Expends Energy

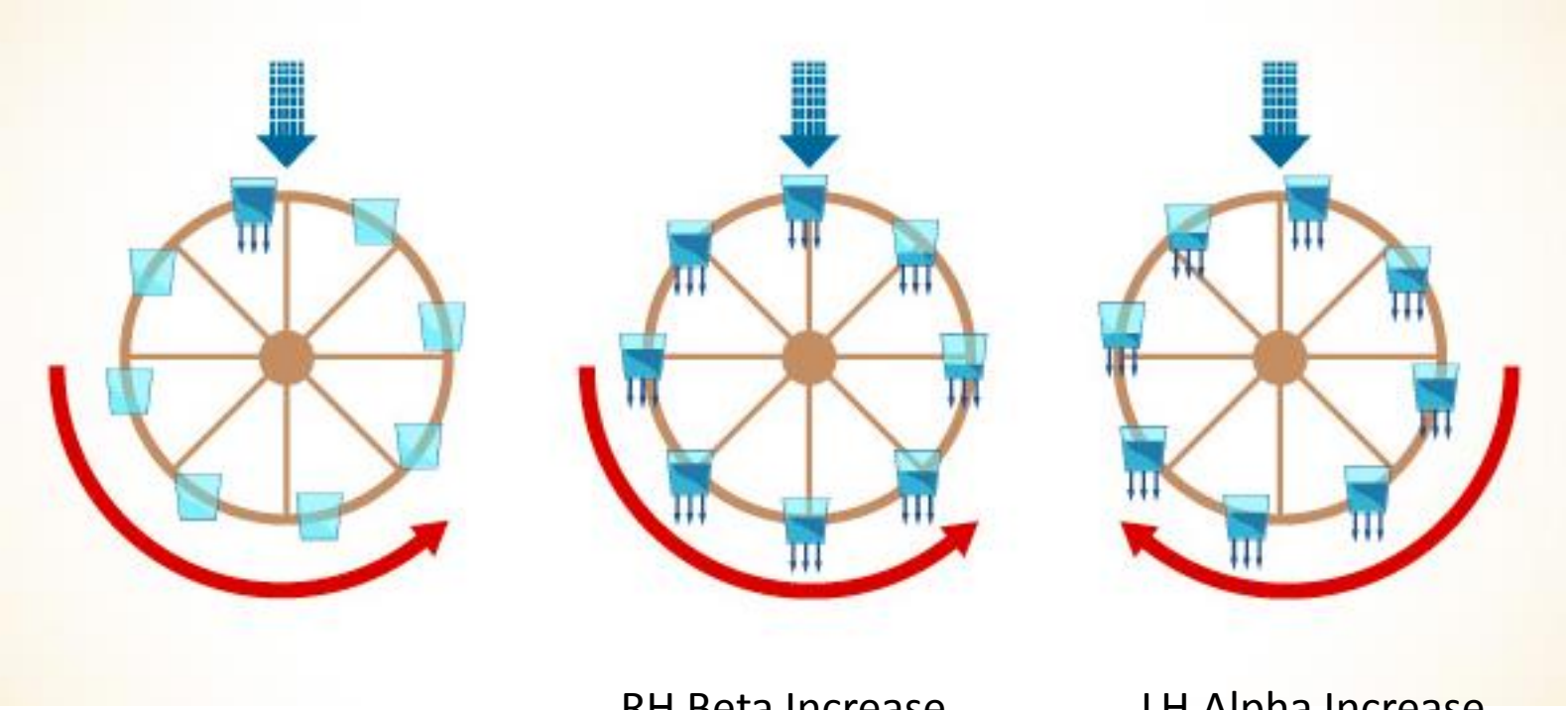
Increases Norepinephrine
Avoidance Behavior
Negative Emotions
Anger Fear Disgust

Escalating Stress & Asymmetrical Neuronal Limit Cycle Dynamics

Initial Stress

Increasing Stress

Overwhelming Stress

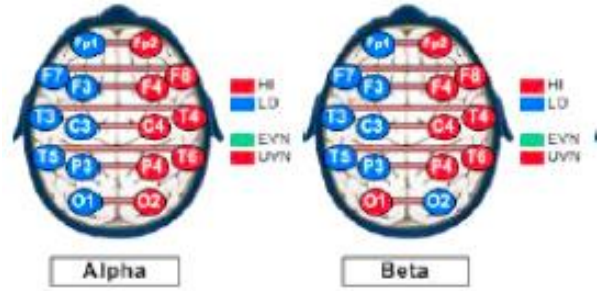


RH Beta Increase

LH Alpha Increase

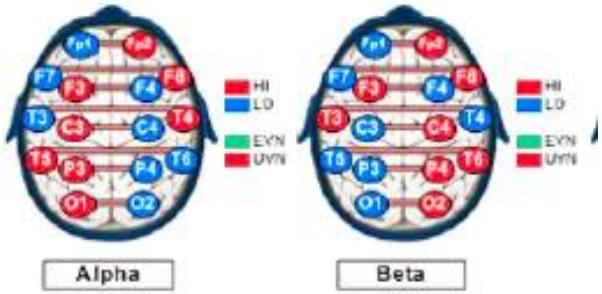
Phases of Cycles

Period 1



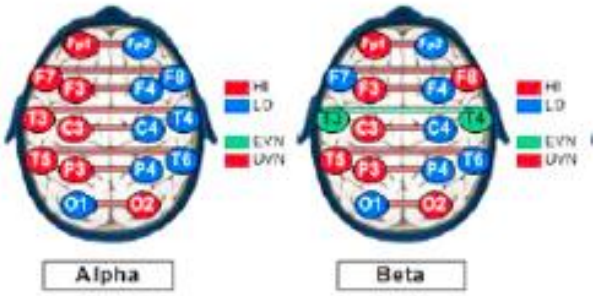
Anxiety

Period 2



Anxiety With Depression

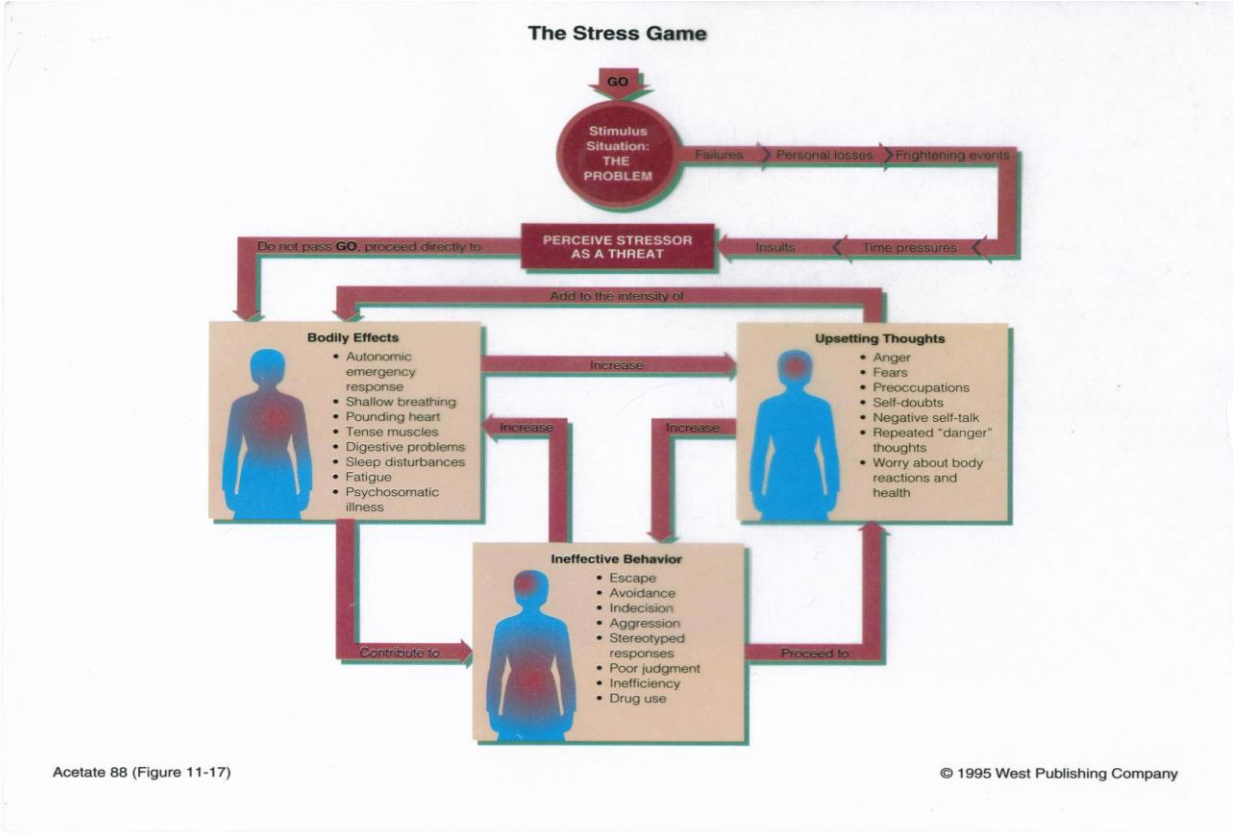
Period 3



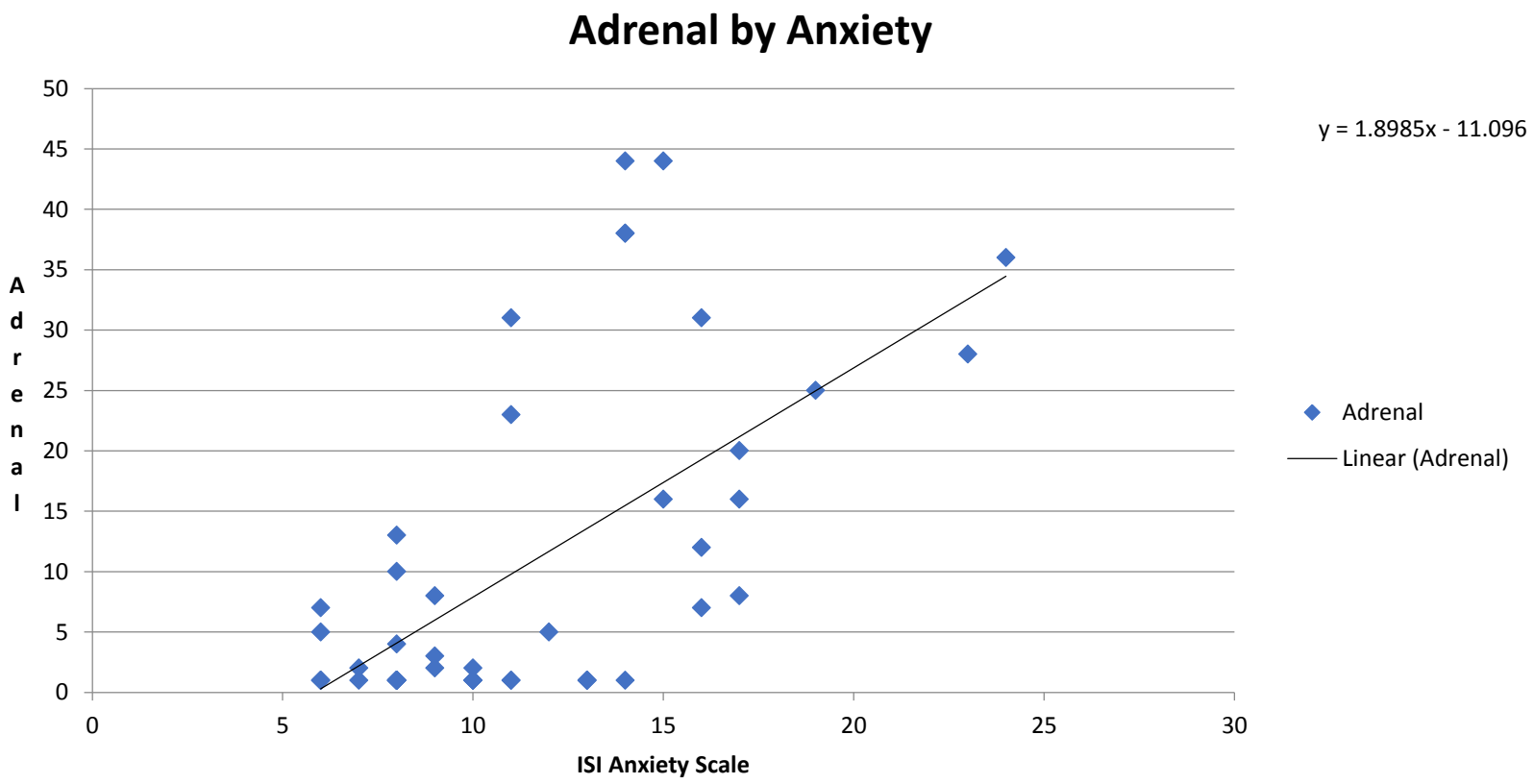
Depression

Chronic Stress and RH Activation

Excess Chronic Energy Expenditure



Correlation .719 between Anxiety measures on ISI and Adrenal Symptoms on CEC Checklist



N = 78: Volunteer Sample

Recognized by Replicated Designs

Psychophysiology, 44 (2007), 352–363. Blackwell Publishing Inc. Printed in the USA.

DOI: 10.1111/j.1469-8986.2007.00518.x

Specificity of regional brain activity in anxiety types during emotion processing

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Abstract

The present study tested the hypothesis that anxious apprehension involves more left- than right-hemisphere activity and that anxious arousal is associated with the opposite pattern. Behavioral and fMRI responses to threat stimuli in an emotional Stroop task were examined in nonpatient groups reporting anxious apprehension, anxious arousal, or neither. Reaction times were longer for negative than for neutral words. As predicted, brain activation distinguished anxious groups in a left inferior frontal region associated with speech production and in a right-hemisphere inferior temporal area. Addressing a second hypothesis about left-frontal involvement in emotion, distinct left frontal regions were associated with anxious apprehension versus processing of positive information. Results support the proposed distinction between the two types of anxiety and resolve an inconsistency about the role of left-frontal activation in emotion and psychopathology.

Descriptors: fMRI, Anxiety, Anxious apprehension, Anxious arousal, Emotion, Stroop

Three Categories of Learned Automated Responses To Fear

With Neurophysiological Correlates

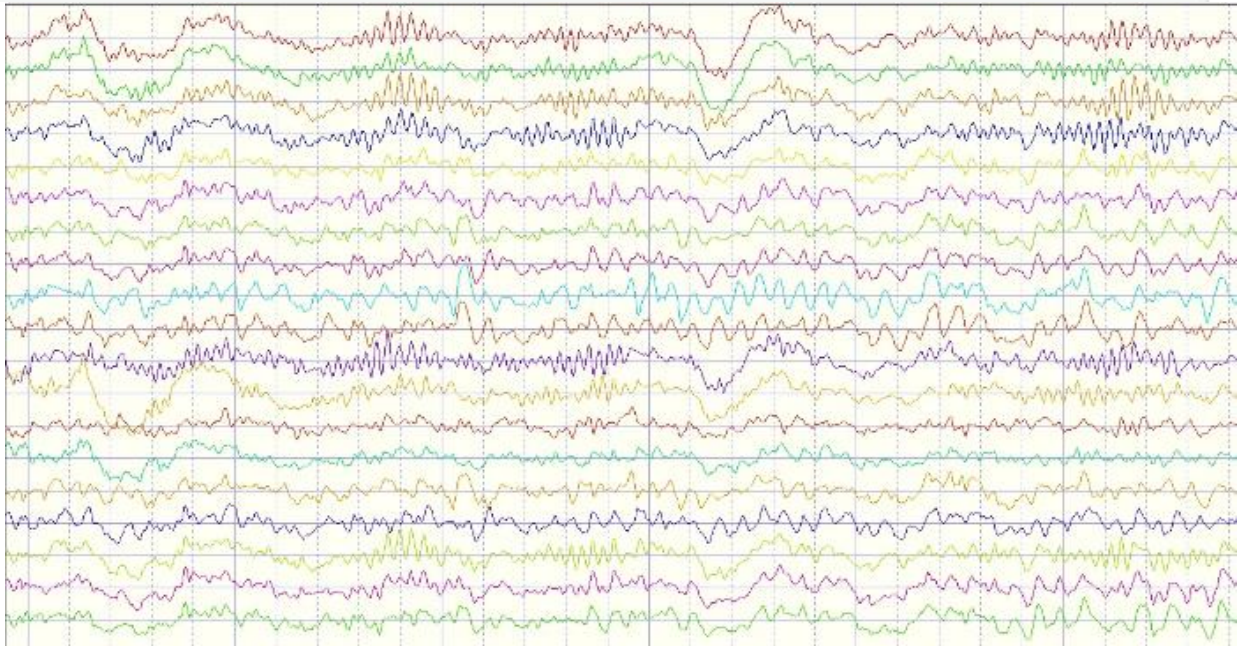
Anticipatory (Worry) Future- What If?

Reactive (Physiological) Present- Oh No!

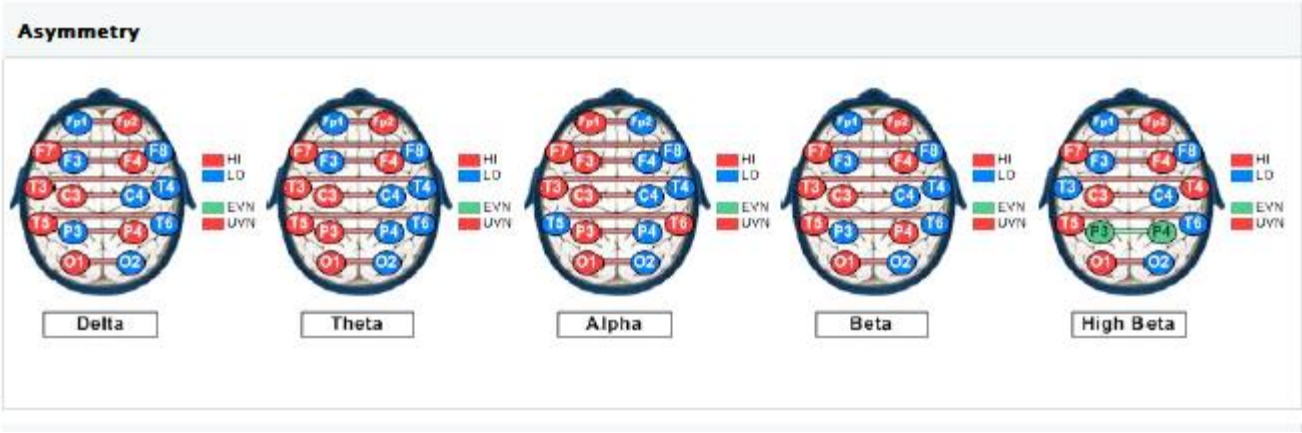
Ruminative (Routinized) Past- Why Did?

Engels et al, 2007

Anticipatory Anxiety



Metabolics Etc



CEC Response Assessment

Category	Response Count	Average Response	Category Score
Attention	5	2.20	11.00
Memory	10	2.00	20.00
Impulsive	2	2.00	4.00
Depression	6	1.83	11.00
Anxiety	9	2.00	18.00

* Red indicates an abnormally high score.

Probability Score	Metabolic Category	Symptoms Reported
1	Pituitary	Headaches
2	Blood Sugar	Headaches Crave Sweets
1	Gastrointestinal	Abdominal pain Stomach Pain
1	Kidney	Headaches
1	Gall Bladder	Itchy Skin
1	Adrenals	Headaches
1	Somatic	Headaches

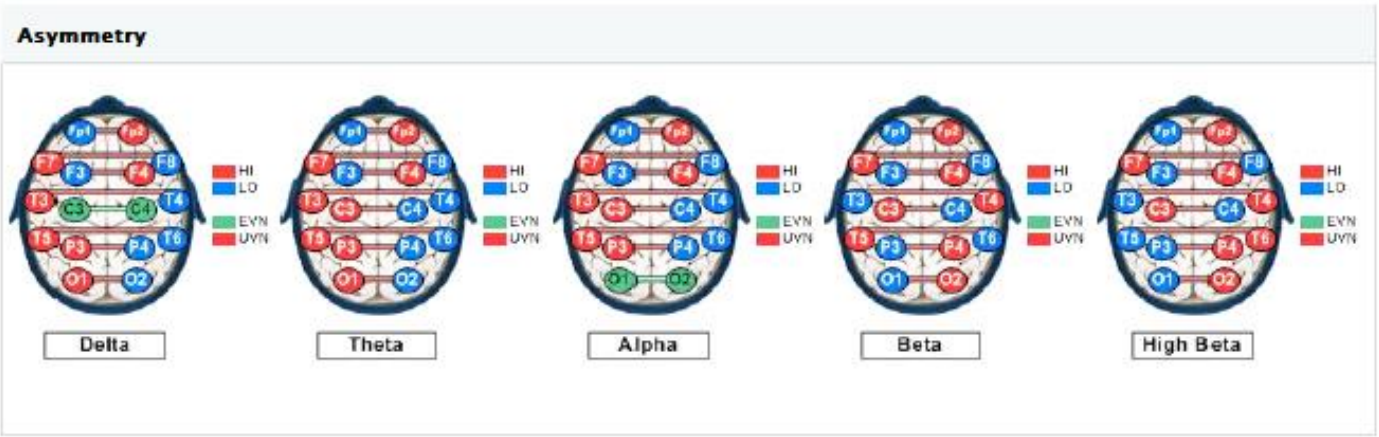
Probability Legend

Minimal Low Moderate High

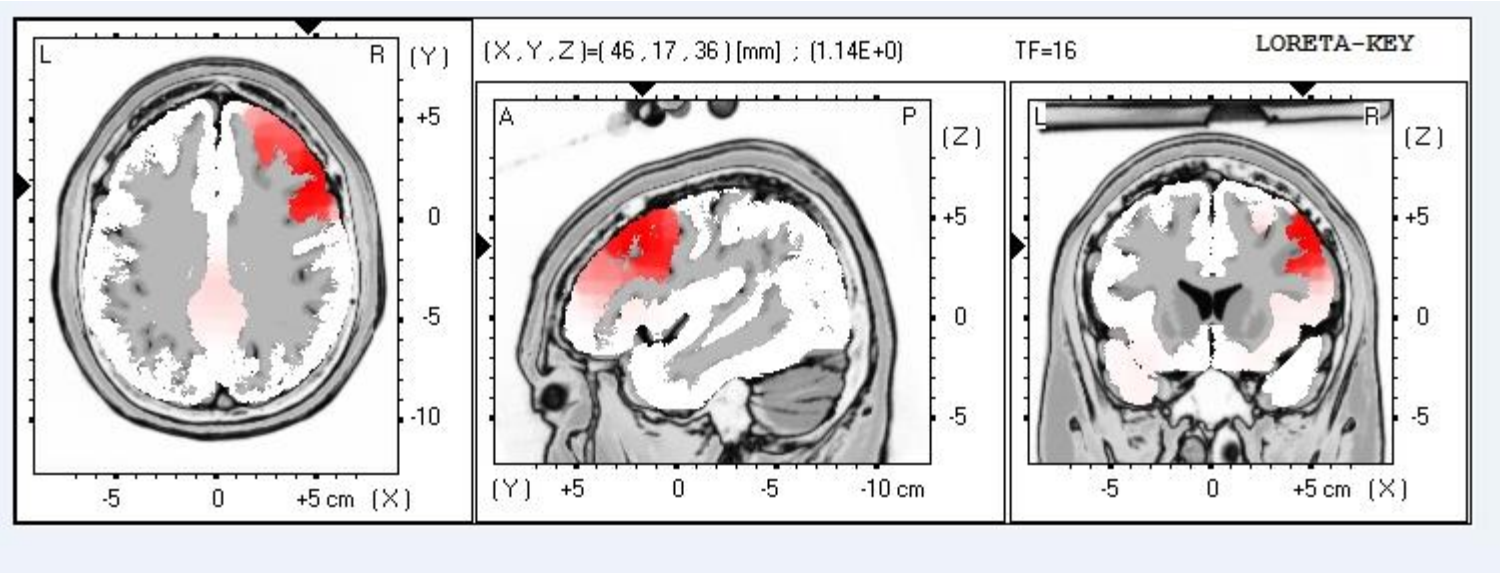
Panic

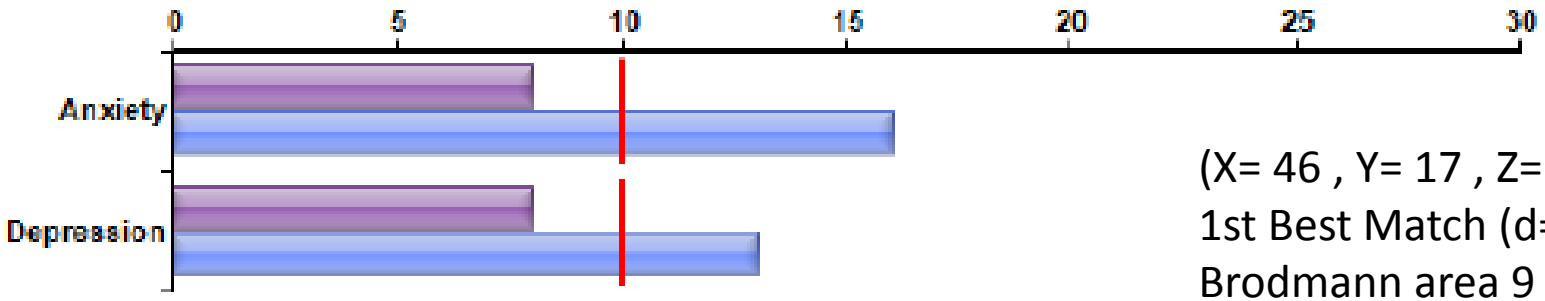

Relative Power
Delta
Theta
Alpha
Beta
High Beta


Absolute Power


Asymmetry
Delta
Theta
Alpha
Beta
High Beta

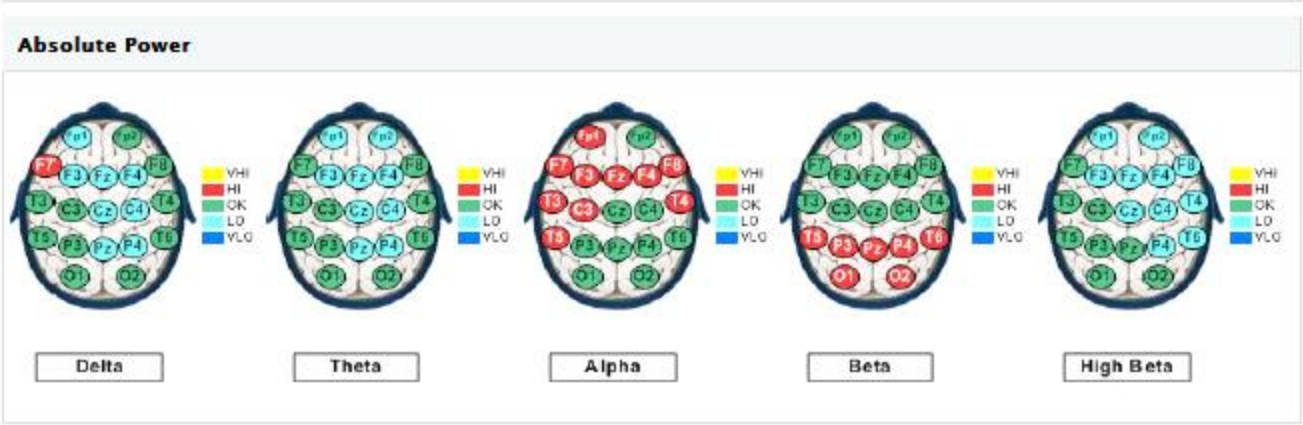
Panic LORETA
Right Frontal Beta





(X= 46 , Y= 17 , Z= 36)
1st Best Match (d= 4 mm)
Brodmann area 9
Middle Frontal Gyrus
Frontal Lobe

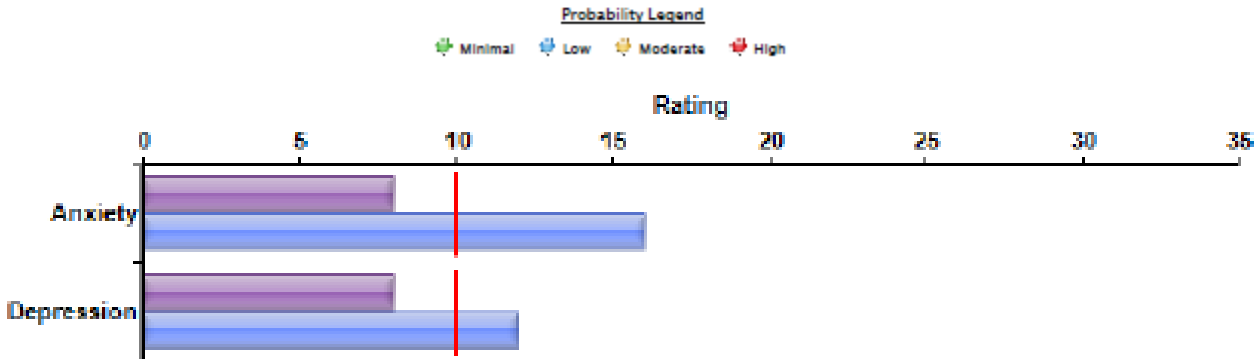
Rumination
Posterior Beta



Chronic Anxiety

Beta Metabolics

Probability	Score	Metabolic Category	Symptoms Reported
	18	Pituitary	Headaches Insomnia
	10	Thyroid (hypo)	Hair Thinning
	8	Cardio-Vascular	Sleepiness
	6	Thyroid (hyper)	Insomnia
	8	Adrenals	Headaches Insomnia
	4	Kidney	Headaches
	5	Blood Sugar	Headaches Nausea Crave Sweets
	3	Gastrointestinal	Nausea Heartburn
	2	Liver	Nausea
	1	Somatic	Headaches
	1	Gall Bladder	Heartburn



Depression Studies: NFB

Original Paper

Neuropsychobiology

Neuropsychobiology 2011;63:43–51
DOI: 10.1159/000322290

Received: September 21, 2009
Accepted after revision: March 16, 2010
Published online: November 9, 2010

Is Alpha Wave Neurofeedback Effective with Randomized Clinical Trials in Depression? A Pilot Study

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Training Asymmetry Reduces Depression

Key Words
Neurofeedback · Depression · Clinical psychophysiology · EEG biofeedback · Frontal EEG asymmetry

Abstract
Frontal asymmetric activation has been proposed to be the underlying mechanism for depression. Some case studies have reported that the enhancement of a relative right frontal alpha activity by an asymmetry neurofeedback training leads to improvement in depressive symptoms. In the present study, we examined whether a neurofeedback training designed to increase the relative activity of the right frontal alpha band would have an impact on symptoms of depressive subjects suffering from emotional, behavioral, and cognitive problems. Our results indicated that the asymmetry neurofeedback training increased the relative right frontal alpha power, and it remained effective even after the end of the total training sessions. In contrast to the training group, the placebo control group did not show a difference. The neurofeedback training had profound effects on emotion and cognition. First, we replicated earlier findings that enhancing the left frontal activity led to alleviation of depressive symptoms. Moreover, cognitive tests revealed that the asymmetry training improved performance of executive function tests, whereas the placebo treatment did not show improvement. We preliminarily concluded that the asymmetry training is important for controlling and regulating emotion, and it may facilitate the left frontal lobe function.

Introduction

Depressed patients show relative hypoactivation in the left prefrontal area, which differs from that found in normal people who show relative hyperactivation in the left prefrontal area compared to the right frontal area [1–3]. This phenomenon was observed in remitted depressed patients [1] and children of a depressive mother [4]. This observation suggests that an impairment in the left prefrontal function may indicate susceptibility to depression [5].

Some scientists have attempted to modulate the susceptibility by increasing left frontal activity. Repetitive transcranial magnetic stimulation (rTMS) and neuro-

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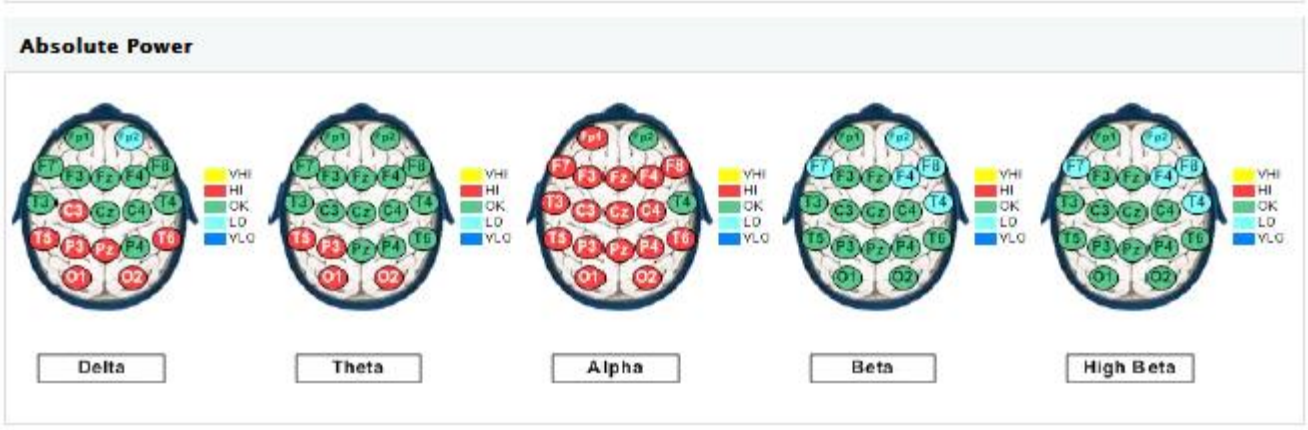
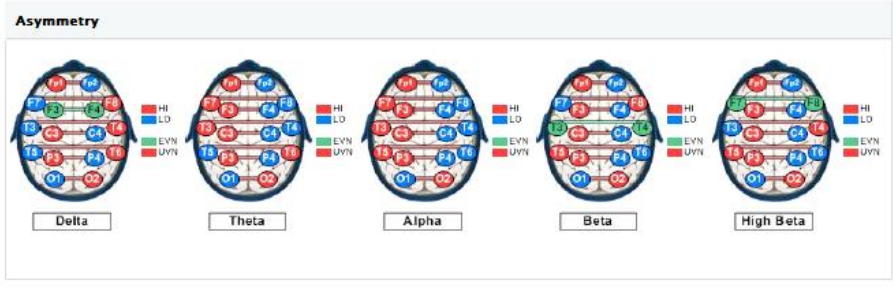
Depression



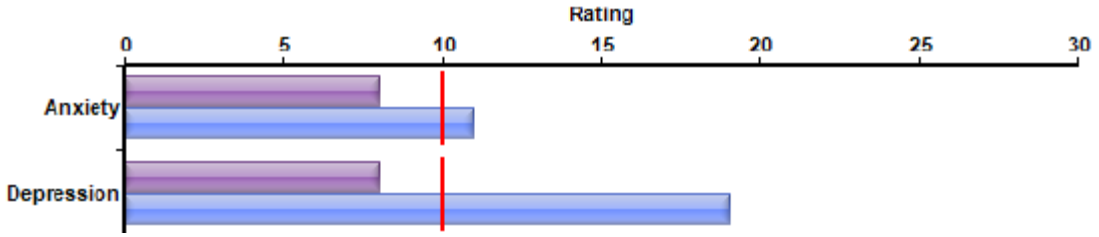


MillerT

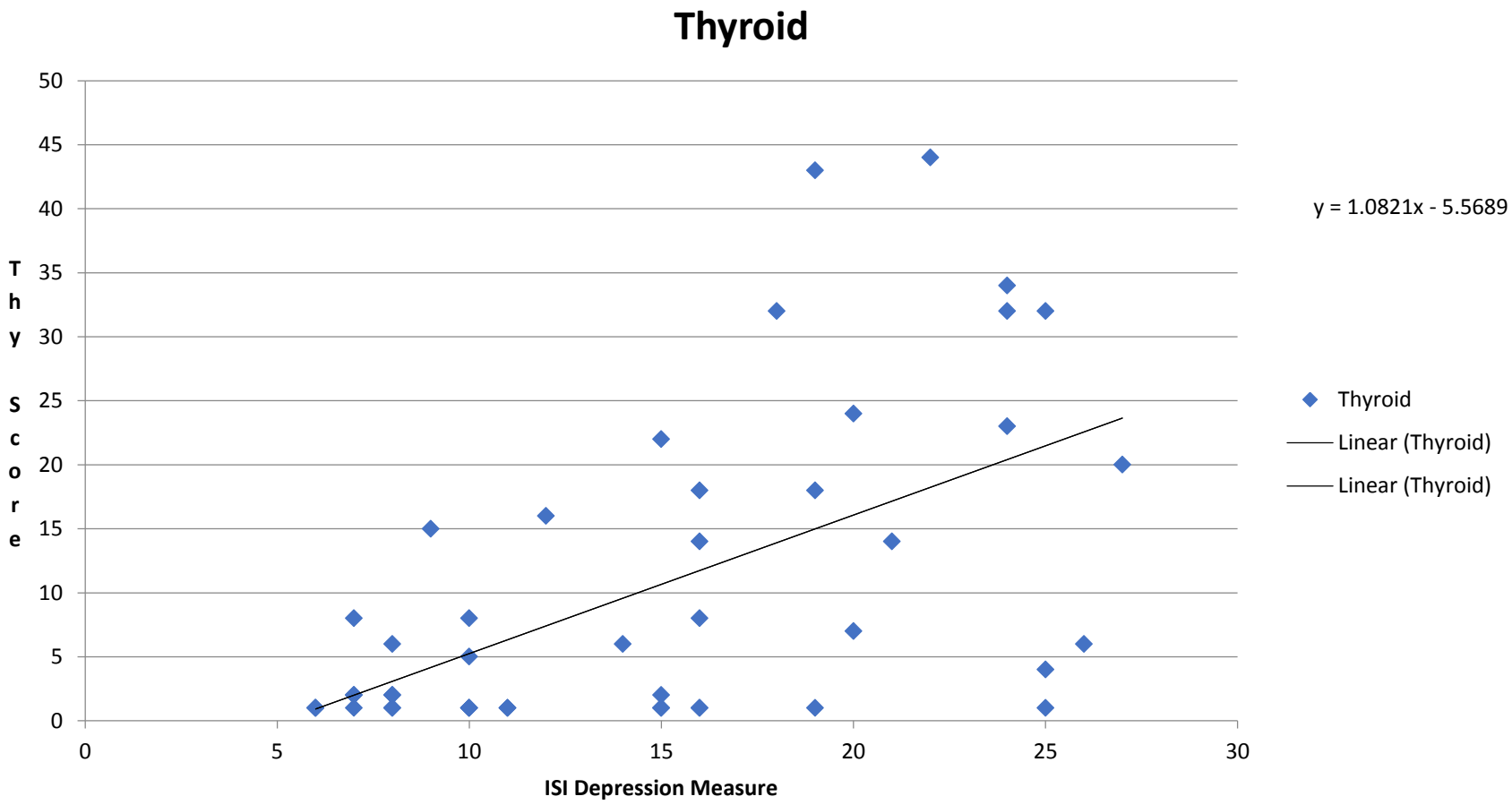
Metabolic Profile Of Depression

Probability Score	Metabolic Category	Symptoms Reported
13	Pituitary	Headaches Insomnia
12	Cardio-Vascular	Heart palpitations Sleepiness Shortness of Breath Ringing in Ears
9	Thyroid (hyper)	Heart palpitations Insomnia Heart racing
11	Adrenals	Headaches Heart palpitations Insomnia Non-restorative sleep
6	Somatic	Headaches Back pain Shortness of Breath Tics-verbal or motor Frigidity (absence of orgasm)
4	Kidney	Headaches Joint pain
5	Gastrointestinal	Abdominal bloating Abdominal pain Stomach Pain

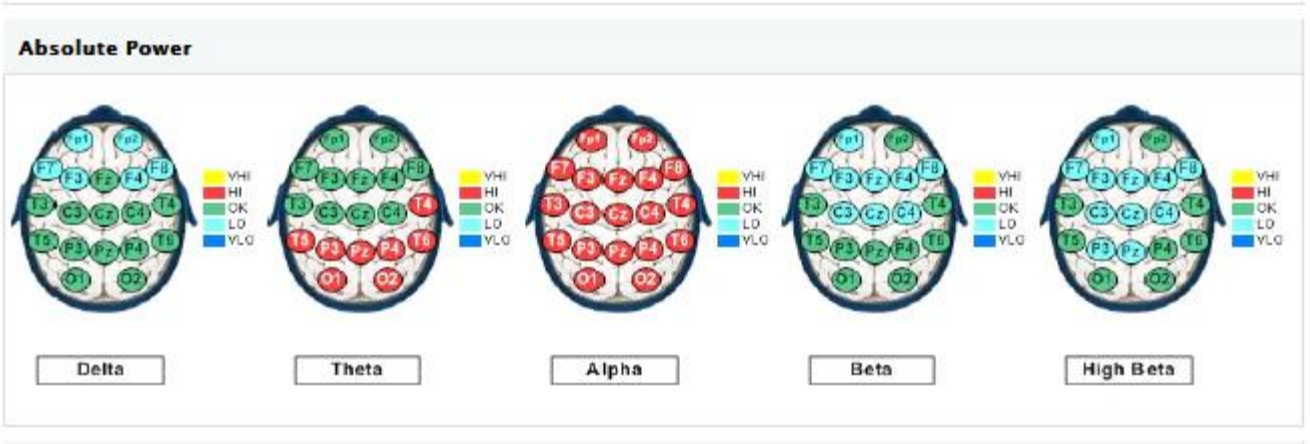
Report intended for exploratory data analysis only and should not be considered a medical diagnosis.

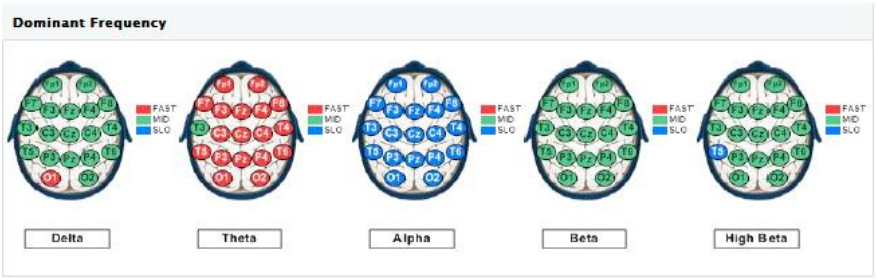


Correlation of Depression Measures and Hypothyroid Symptom Measures (N =48) .574



Anxiety Transitions to Depression

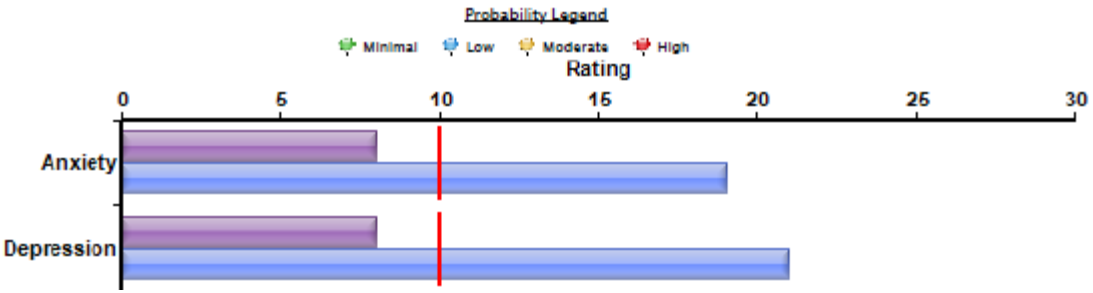




Provenzano

Transition Metabolic Profile

Probability Score	Metabolic Category	Symptoms Reported
10	Pituitary	Headaches Insomnia Menstrual irregularity
12	Thyroid (hypo)	Sexual indifference Fatigue Cold all the time Hair Thinning
8	Kidney	Headaches Fatigue
6	Cardio-Vascular	Fatigue Sleepiness
8	Adrenals	Headaches Insomnia Fatigue Non-restorative sleep
5	Blood Sugar	Headaches Numbness Agitation Crave Sweets Caffeine Dependent
3	Liver	Sexual indifference Fatigue
1	Thyroid (hyper)	Insomnia Night Sweats
1	Somatic	Headaches Numbness
1	Gastrointestinal	Abdominal bloating



Horizontal vs Vertical Domains of Training

- Horizontal focus is on limbic integration.

  Anxiety and Mood Stabilization.

- Vertical focus is on cognitive integration.

  Arousal relating to attention and memory.

Training one domain normalizes the compensating domain.

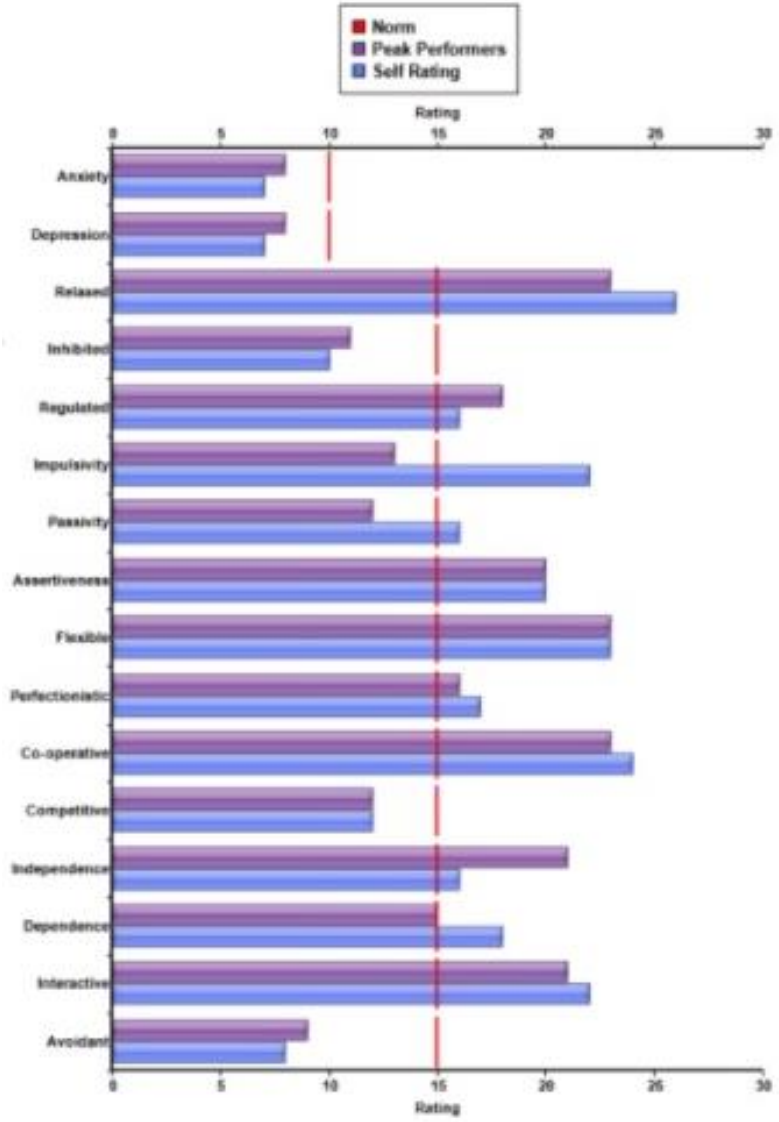
Horizontal Integration

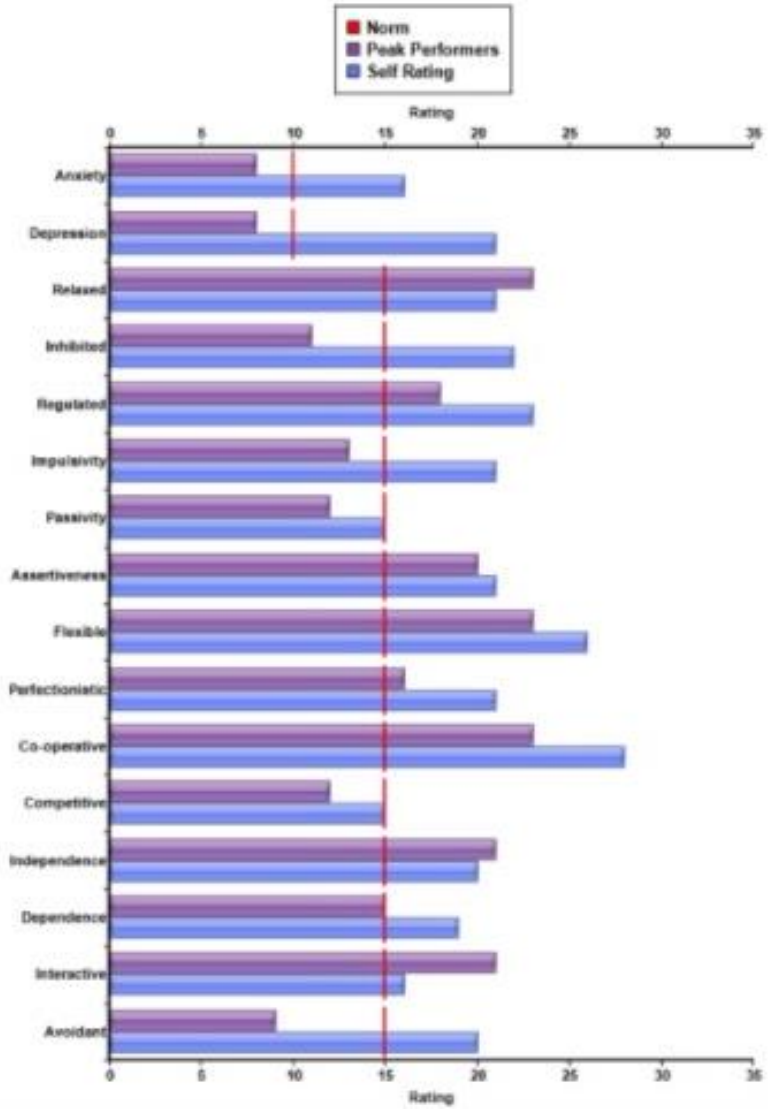
- A Bilateral Asymmetry Measure
- Looks at the relationship between magnitude asymmetry, and coherence between hemispheres.
- Is primarily related to affective plasticity measures (Alpha Asym for Depression and Beta Asym for Anxiety.)

Vertical Integration

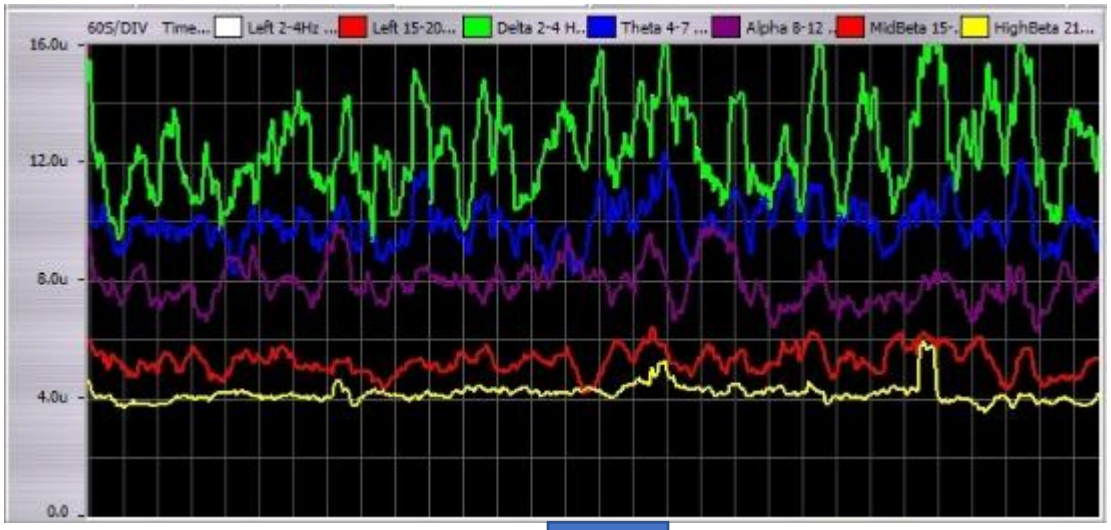
- Looks at measures of cooperation in the triune brain.
- Is based primarily on magnitude measures (ratio of fast to slow wave activity.)
- Determines the inhibitory control of the cortex with respect to subcortical structure.
- Is mostly related to cognitive performance as a function of arousal measures.
- Slow wave to fast wave ratio (delta + theta/ beta) is an indicator of general mental activation (mental arousal) level (Panksepp, 2003; Shutter et al, 2005; Pop-Jordanov & Pop-Jordanov, 2005).

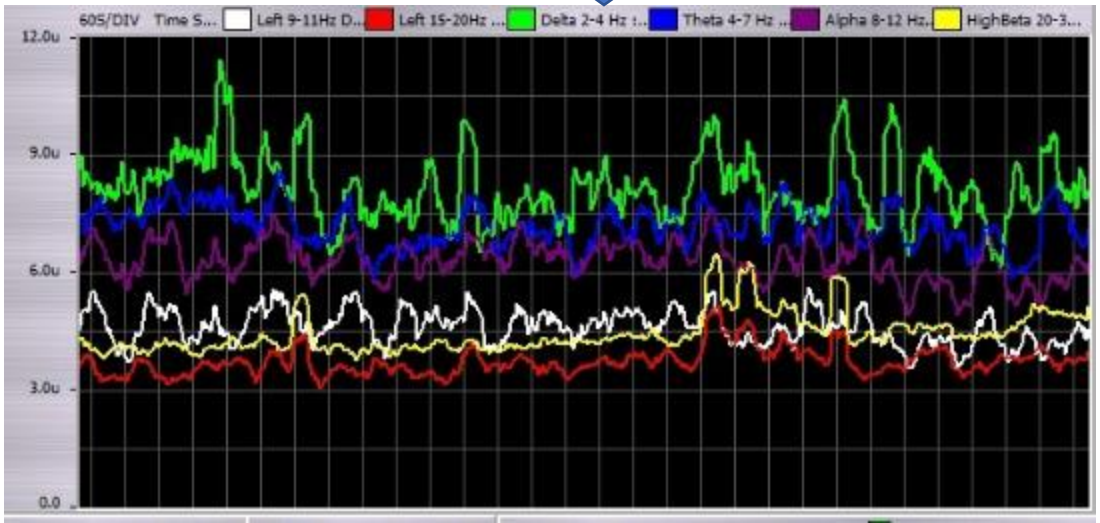
ISI Flight Ready vs Off Line Pilot



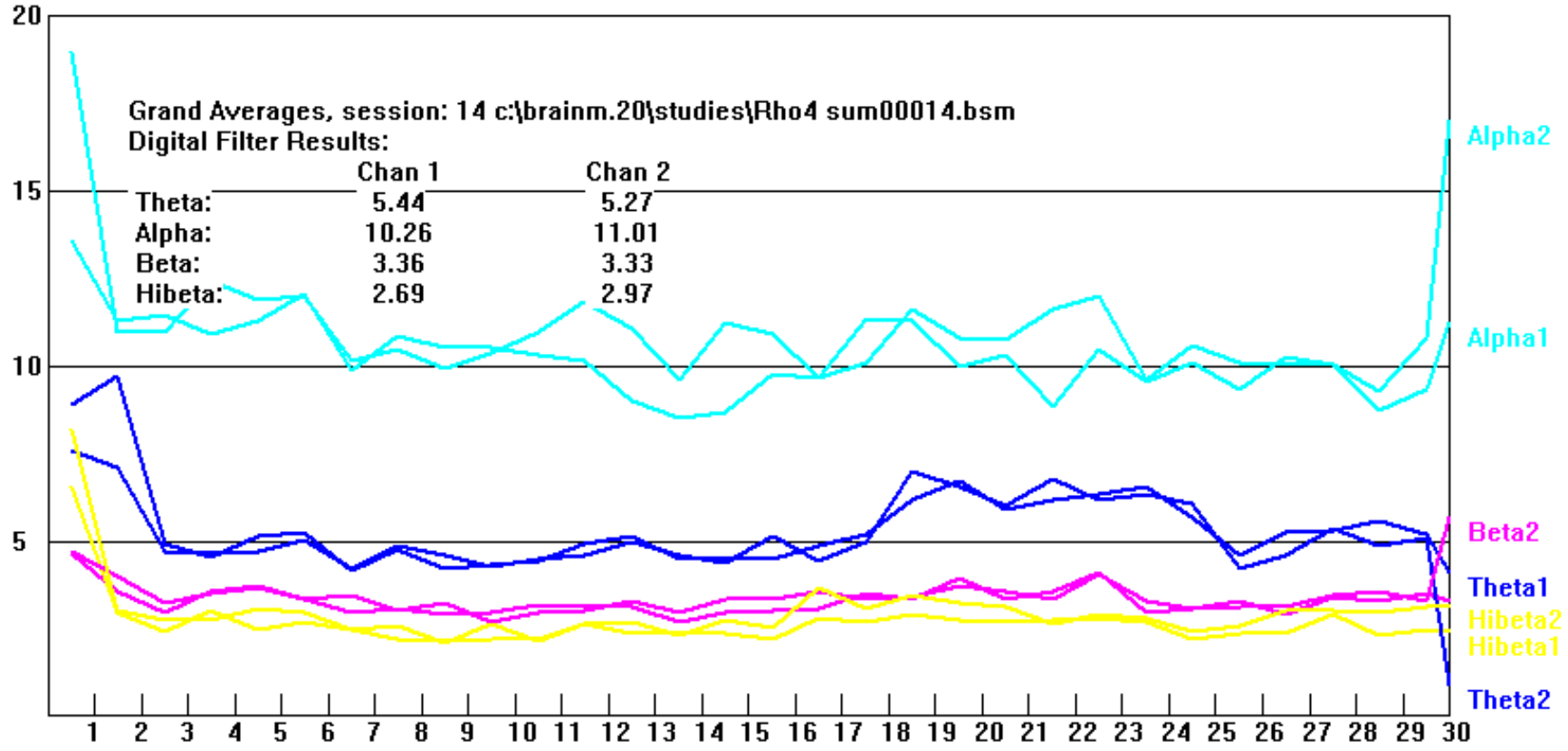


Vertical Compression





Horizontal Convergence and Compression



Normal EEG Amplitudes

Eyes Open- Dorsal

- Delta- 12uv
- Theta- 10uv
- Alpha- 9uv
- Beta- 5uv

+/- 30%

Eyes Closed- Dorsal

Alpha- 12

Theta- 10

Delta- 9

Beta- 6

+/- 30%

Ventral – Reduce above values by 30-40%

These Are Rough Estimates

Training Template: Phase 1

- Train Mood first- 15 sessions Horizontal Domain.

Usually Frontal Sites (F3-F4) with asymmetry type of protocol.
Symptoms improve around session 6-10.
Clients may begin dreaming, feel agitation, show irritability and have difficulty sleeping session 10-15.
Integration period may last up to 2 weeks.
Measure changes with symptom tracker and ISI.
Begin Training posterior site for overarousal and anxiety next.
It integration continues with anxiety then PTSD Likely- Use AT.

Training Template: Phase 2

Train Anxiety Second- 10-15 sessions.

Usually Posterior sites O1-O2 with Asymmetry type protocol.
Anxiety decreases around session 20-30.
May require additional training.
Measure Change with symptom tracker and ISI.
Clients develop insights into behavior and circumstance.
Clients emit novel behaviors that shift locus of control.
Self-awareness increases around ineffective behaviors.
Energy improves and clients are less reactive when challenged.
If unresponsive shift to AT training.
Train Cognitive next.

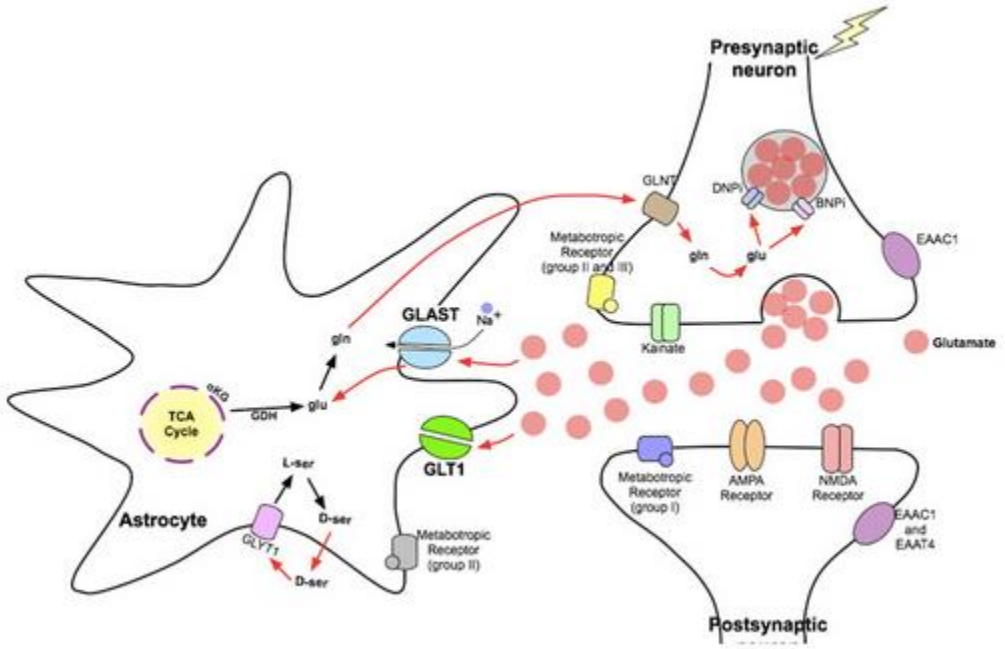
Energy Requirements:
Neuronal ATP

- Neurons require high levels of energy in order to operate, especially in beta frequencies.
- They require exceedingly high demand for ATP.
- Diminished production of ATP can affect normal neuronal function.
- This reduced function of neurons translates into reduced high frequency production.
- Loss of high frequency shifts Slow to Fast wave ratio and increases idling.

Astrocytes Fail To Recycle Glutamate

Excess glutamate output and related inflammation reduce microglial capacity to convert glutamate to glutamine for recycling.

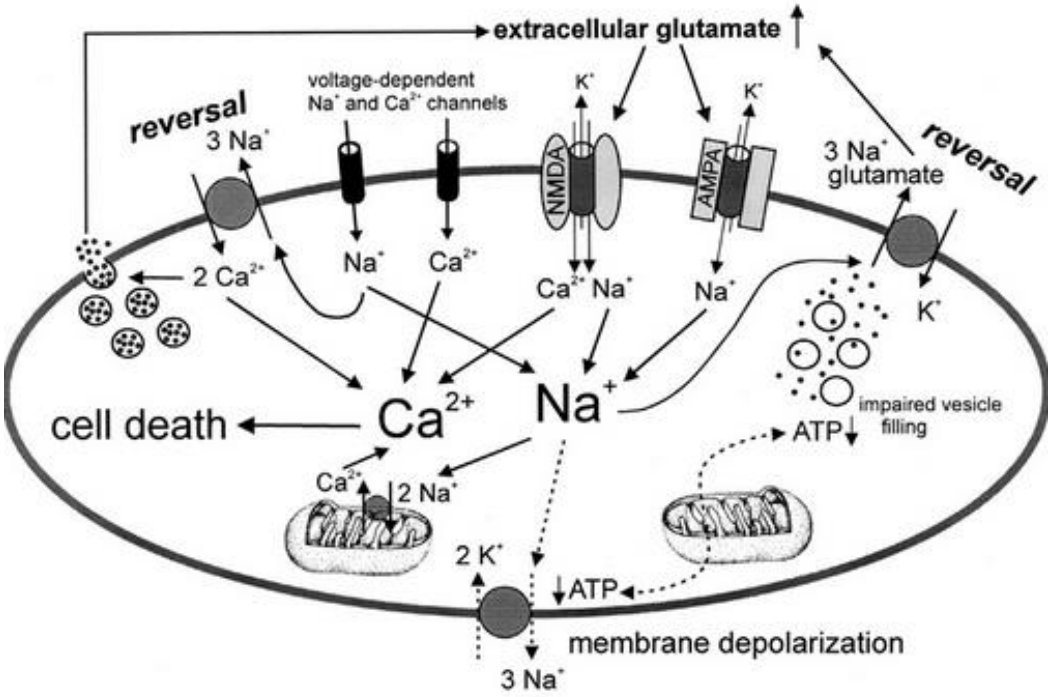
This results in excessive extra cellular glutamate.



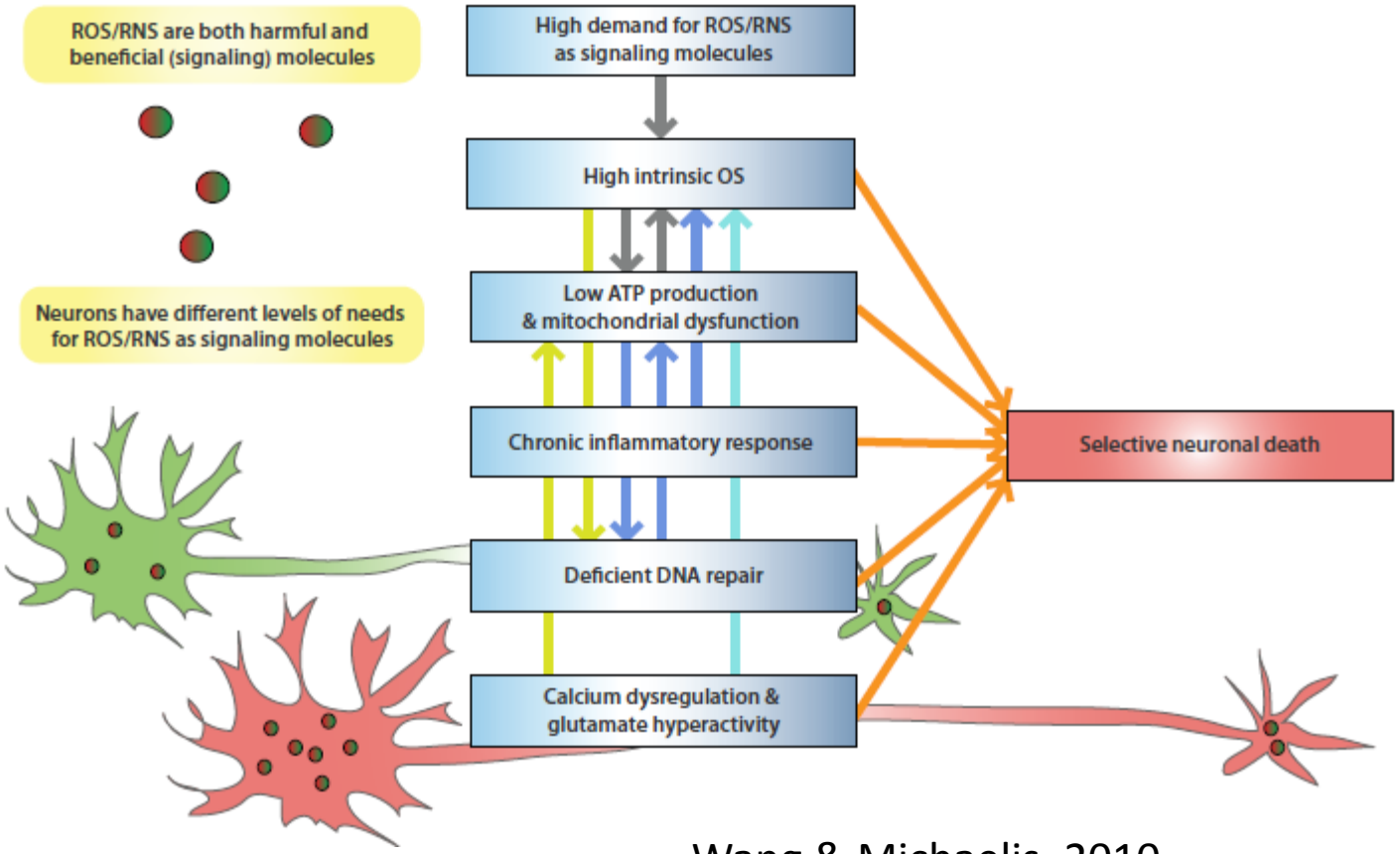
Neuronal Damage

Glutamate Mediated Excitotoxicity

The excessive extracellular glutamate binding to NMDA receptors allows entry of Ca2 into the postsynaptic neuron, causing necrotic cell death or apoptosis, whereas the excessive glutamate binding to non-NMDA receptors allows entry of Na into the postsynaptic neuron, resulting in cytotoxic edema.



The Excitotoxic Model



Wang & Michaelis, 2010

Quinolinic Acid & Depression

A pro-inflammatory response

Tryptophan is converted to QA instead of Serotonin

Increases output of glutamate

Reduces the uptake of glutamate

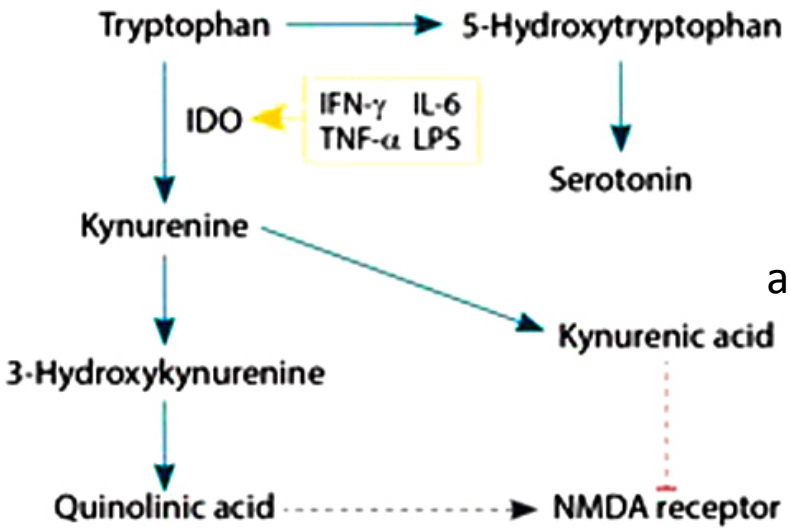
Results in lipid peroxidation

Generates Apoptosis

Kynurenic Pathway

What is not so obvious is that serotonin is also affected by inflammation. Serotonin levels decrease in individuals with a chronic inflammatory condition, due in part to the shunting of tryptophan down the kynurenine pathway (Figure 1).[1]

Figure 1



antiexcitotoxic and anticonvulsant

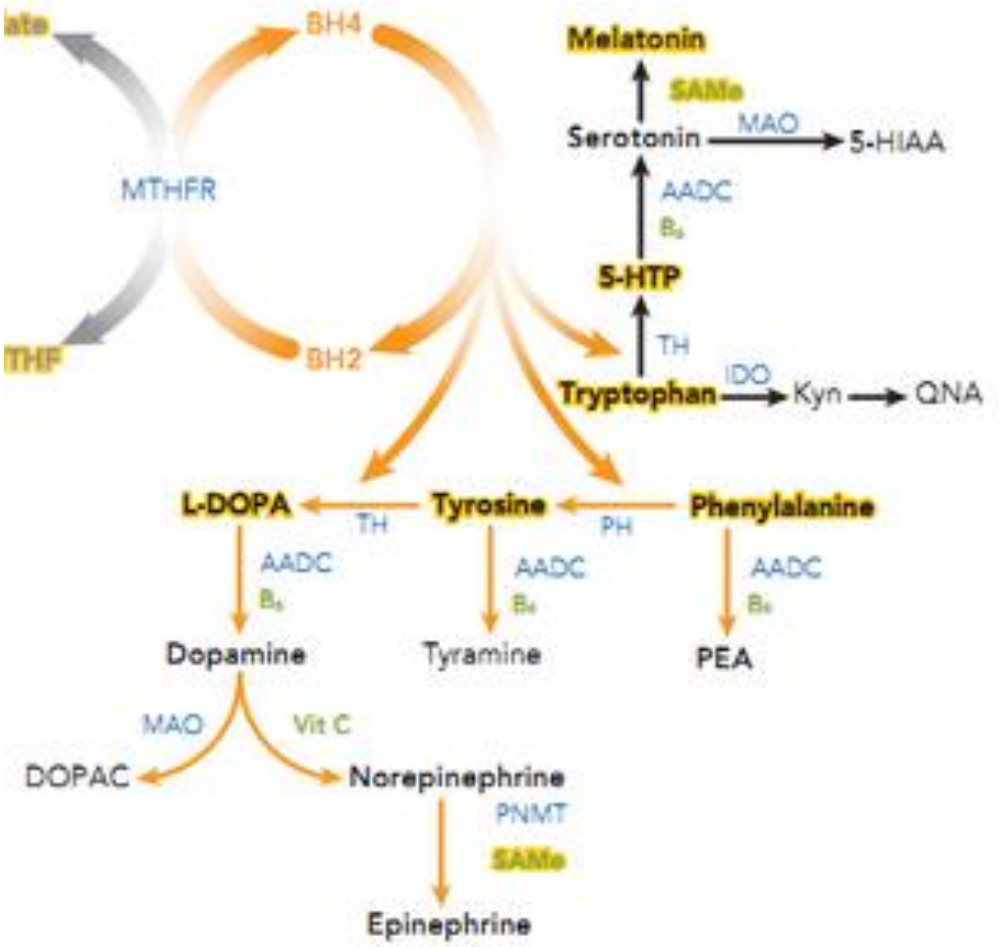
Activation of certain cytokines (such as IL-6, IFN-g, TNF-a, and LPS) can lead to activation of indoleamine 2, 3-dioxygenase (IDO), which shunts tryptophan down the kynurenine and quinolinic acid pathways, resulting in suboptimal serotonin levels.[2]

Gut Brain Axis

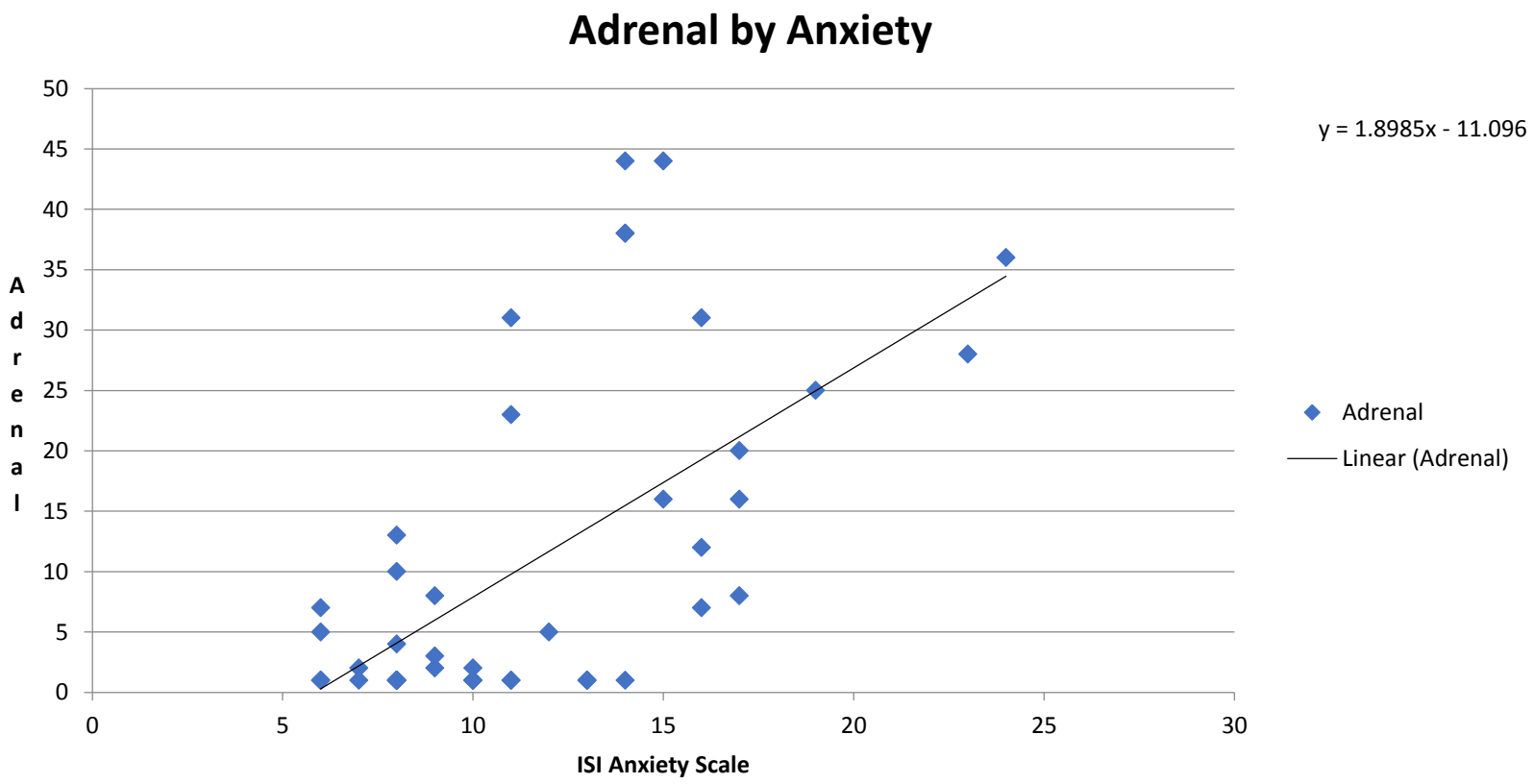
- Changes in gut microbiome communicate with serotonin pathways in the brain.
- Gut microbiota control host tryptophan metabolism along the kynurenine pathway.
- Kynurenine pathway is stress and immune responsive.
- Influences serotonin vs quinolinic acid production.

O'Mahoney et al, 2015

Neurotransmitter Production

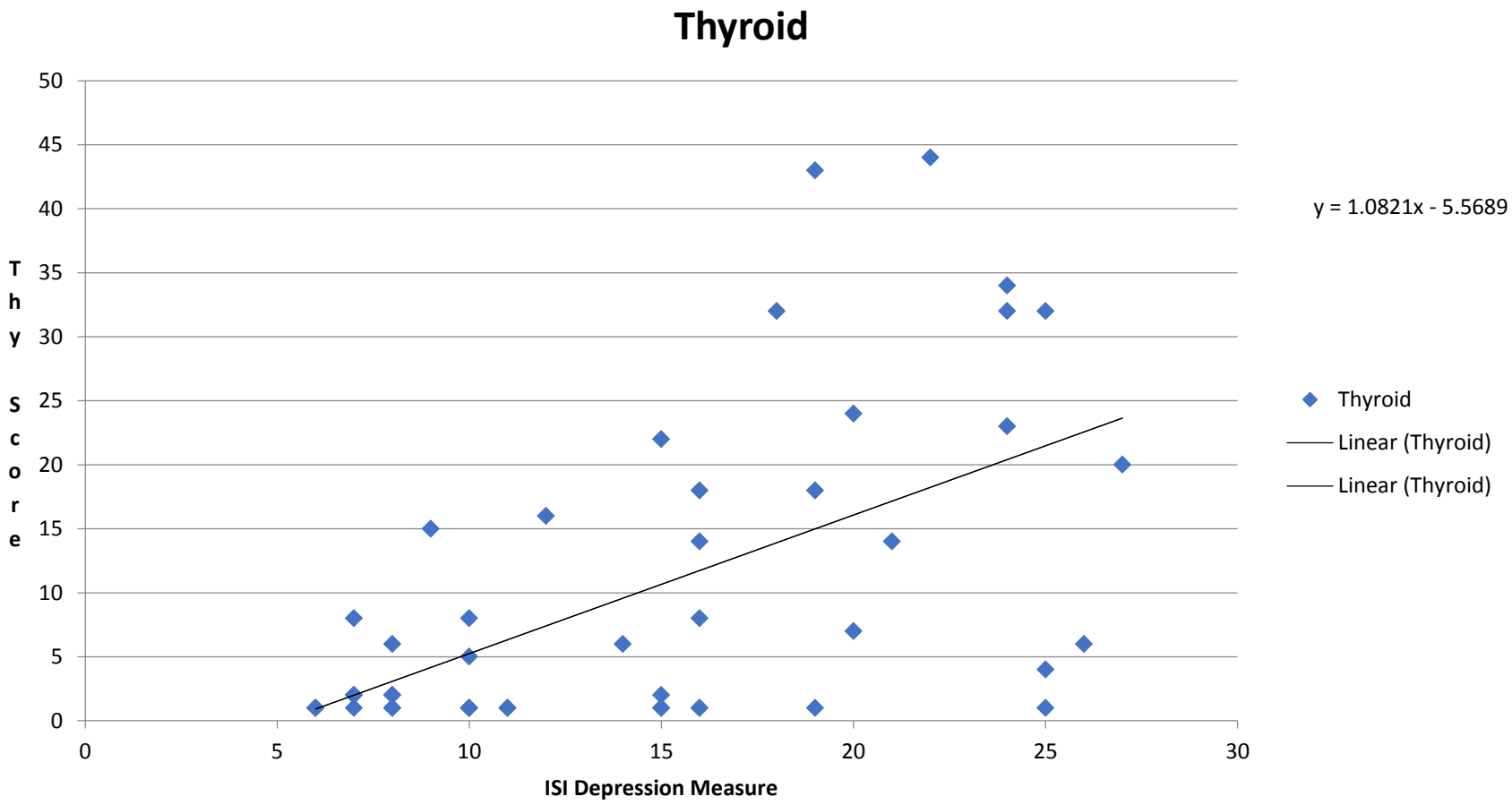


Correlation .719 between Anxiety measures on ISI and Adrenal Symptoms on CEC Checklist

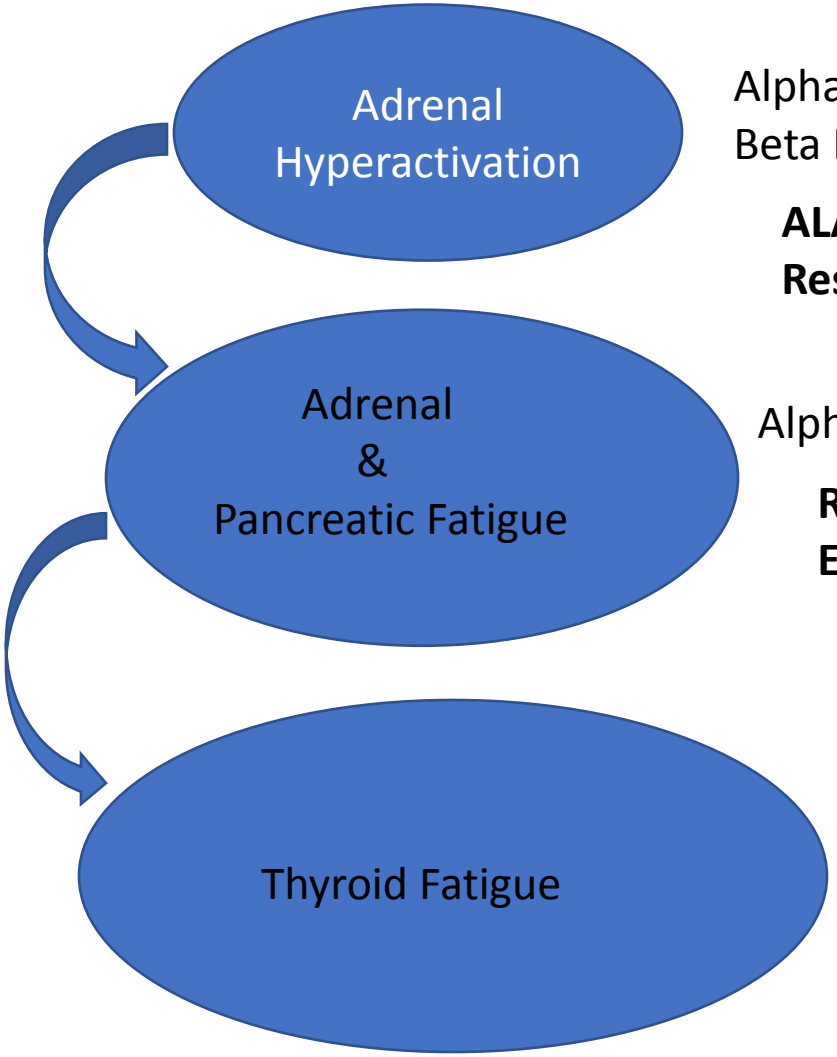


N = 78: Volunteer Sample

Correlation of Depression Measures and Hypothyroid Symptom Measures (N =48) .574



Oxidative Stress Cycle and qEEG



Alpha Decreases
Beta Increases

ALARM & Resistance

Calcium, Mag decrease
Sodium, cortisol, glucose increase
Increasing Acidosis

Alpha + Beta Deficit

RESISTANCE & Exhaustion

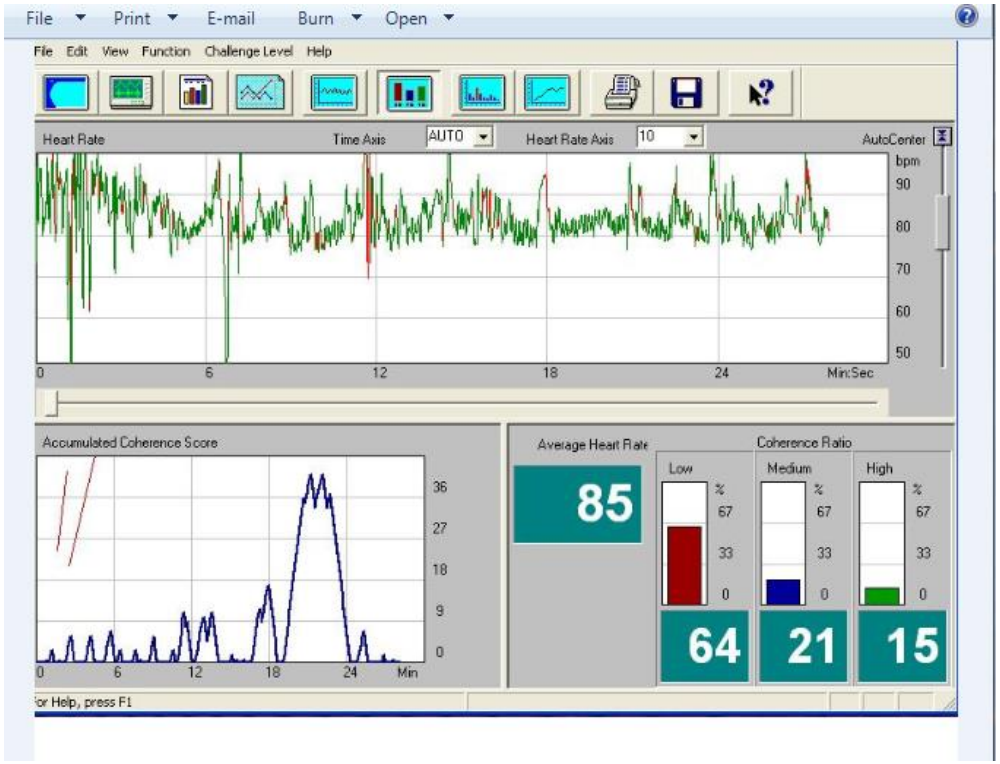
Potassium decreasing
Glutimate increasing
Insulin, cortisol decreasing
Blood Sugar decreasing
GI flora shift
DHA, B12, B6, Folic Acid deficits
Inflammation Increasing

High Amplitude Low Frequency Alpha
Eventually shifts to
High Amplitude Theta

EXHAUSTION

Selenium Low
Cortisol, T3, ATP depleted
Inflammation High
Ion Pumps Compromised

HRV Physiology of Anxiety & Depression



Stress & The Endocrine System

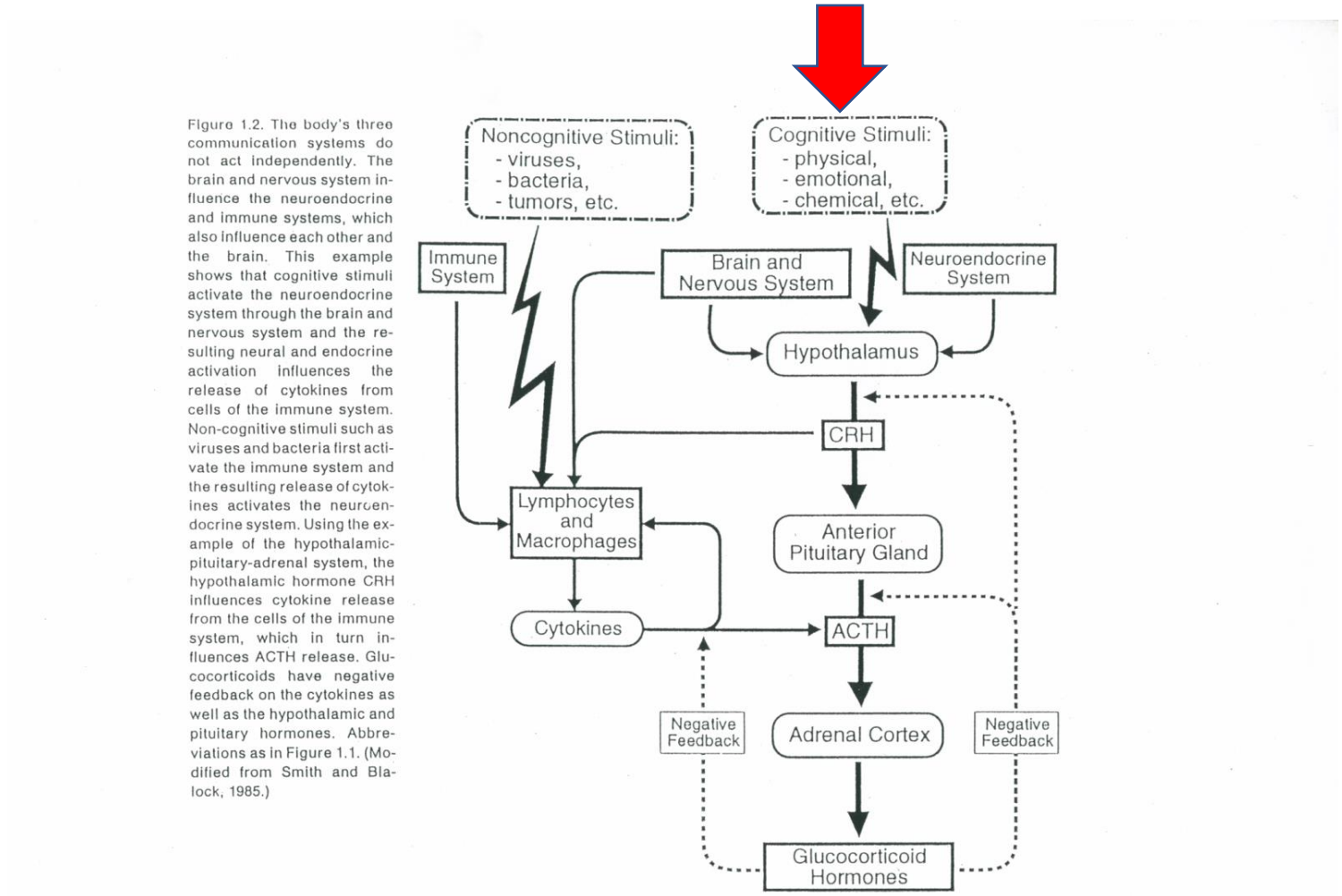


Figure 1.2. The body's three communication systems do not act independently. The brain and nervous system influence the neuroendocrine and immune systems, which also influence each other and the brain. This example shows that cognitive stimuli activate the neuroendocrine system through the brain and nervous system and the resulting neural and endocrine activation influences the release of cytokines from cells of the immune system. Non-cognitive stimuli such as viruses and bacteria first activate the immune system and the resulting release of cytokines activates the neuroendocrine system. Using the example of the hypothalamic-pituitary-adrenal system, the hypothalamic hormone CRH influences cytokine release from the cells of the immune system, which in turn influences ACTH release. Glucocorticoids have negative feedback on the cytokines as well as the hypothalamic and pituitary hormones. Abbreviations as in Figure 1.1. (Modified from Smith and Blalock, 1985.)

Cognitive & Emotional Stress Affects Endocrine Functions

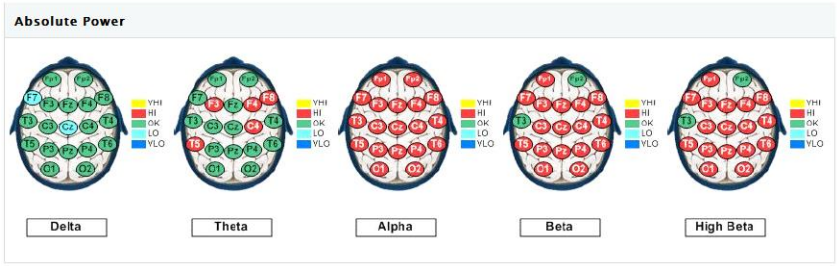
Stages of Oxidative Stress Cycle

1

2

3

4



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