ADD/ADHD Markers in the Context of Cognitive-Emotional Processing

Current Models and EEG-based methods

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Description

- This talk will describe some current developments in a neuroscience-based model of decision-making that incorporates both logic and emotions as key components. The interaction of cognitive processes such as pattern recognition, prediction, and choosing, in combination with positive and negative emotional responses, produce the dynamic responses that underlie individual feeling and behavior, as a personal style. This is relevant to ADD/ADHD, which can be understood in terms of this operational model.

Objectives

- The control of attention is fundamentally a decision-making process. It is affected by patterns of reward and punishment, as well as goal-seeking. The latter can include novelty, security, pleasure, sense of superiority, or need for attention, to mention only a few. Attention is also strongly influenced by mood, in that the brain will tend to focus attention on factors that provide some measure of either a positive/safe/approach decision, a negative/danger/avoid decision, or, more generally, a combination thereof.

- Summarize current understanding relating brain localization and activation to how the brain functions
- Describe how specific individual differences in brain activation patterns reflect how people react to situations.
- Explain why brain-specific learning and imaging methods provide important new capabilities in the area of neuroscience-based mental health care.
- Describe specific examples of individual brain activation patterns in stressful or demanding situations, and how those patterns reflect emotional reactions and performance.

- It is generally found that children with ADD/ADHD who exhibit excess frontal theta, or frontal slow alpha, are inclined to respond favorably to stimulant medication. This is in contrast to children who have other patterns of EEG dysregulation, and who respond differently. The role of stimulant medication in improving behavior can be understood in terms of basic aspects including impulsivity, anticipating consequences, and recognizing possible hazards. By focusing on underlying function rather than observed symptoms, some of the complexity of the "multiple subtypes" of ADD/ADHD can be circumvented. Underlying functional dysregulation patterns thus become biomarkers in their own right, less attached to the diagnosis than they are to the precise dysfunctions at a neuronal level.

- A new method that relates known frontal activation patterns and functions with event-related EEG images has been developed, and will be described. Results from individuals with specific emotional and decision-making agendas will be shown. These reflect the instantaneous brain responses to specific cues. Examples from areas including personal fitness, emotional disorders, criminal justice, and work with addicts and offenders will be presented.

Presenter Bio

- **Dr. Collura** is currently president of BrainMaster Technologies, Inc., and clinical director of the Brain Enrichment Center, in Bedford, Ohio. He received the Ph.D. in 1978 from Case Western Reserve University in Biomedical Engineering for research on visual and auditory evoked potentials and attention. He received the Master of Science in Mental Health Counseling from Walden University in 2013. He served for 8 years on the staff of the Department of Neurology, Cleveland, Clinic, developing computerized EEG monitoring and mapping systems. He is the founder of BrainMaster Technologies, Bedford, OH, a developer of EEG and neurofeedback systems. He has over 20 peer reviewed papers and book chapters in the areas of EEG, evoked potentials, and neurofeedback. He is a past president of the ISNR, and a past president of the neurofeedback division of the AAPB. He recently chaired the IEEE standards effort on Recommended Practice for Neurofeedback Systems, whose standard was approved in 2012.

Appl Psychophysiol Biofeedback
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The Effects of QEEG-Informed Neurofeedback in ADHD: An Open-Label Pilot Study

Martijn Arns · Wilhelmus Drinkenburg · J. Leon Kenemans

1. *Frontocentral Theta/(beta) protocol*: If excess fronto-central theta was observed then the midline site (Fz, FCz or Cz) where this activity was maximal was chosen and the exact theta frequency band was determined from the QEEG report by inspecting the Z-scores for single hertz bins in the theta frequency range. In these patients hence a theta/beta protocol was used with an additional reward on beta (15–20 Hz). When there was beta-excess, only theta would be downtrained and no beta reward was used. When theta was normal but beta was decreased only beta was rewarded.

2. *Frontocentral alpha protocol*: If there was excess fronto-central alpha (especially during eyes open) then the midline site where this activity was maximal was chosen and next this activity was downtrained. If there was no excess beta activity or beta spindles then a beta reward was also used.

3. *Beta-downtraining protocol*: If excess beta or beta spindles were present then the site where this activity was maximal (Z-score) was identified and selected as training site. The exact training frequency was established from the QEEG single Hz bin Z-scores and this frequency was specifically downtrained. No further inhibits or rewards were used.

4. *A low-voltage EEG*: If this type of EEG was observed, then an 'SMR protocol' was used (either rewarding SMR spindles with a 0.25 s. duration, or SMR/theta at C3/C4). When there was also a lack of alpha power during eyes closed, alpha uptraining during Eyes Closed at Pz (*Alpha-uptraining protocol*) was added, as suggested by Johnstone et al. (2005).

5. If there were no clear QEEG deviations and/or if sleep problems were a main complaint, then an 'SMR protocol' was used (the side was chosen based on the location where the 12–15 Hz activity was lowest).

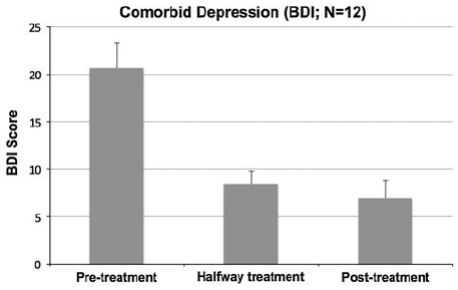
All patients treated have been included in the analysis, including patients who dropped out or who did not respond to treatment.

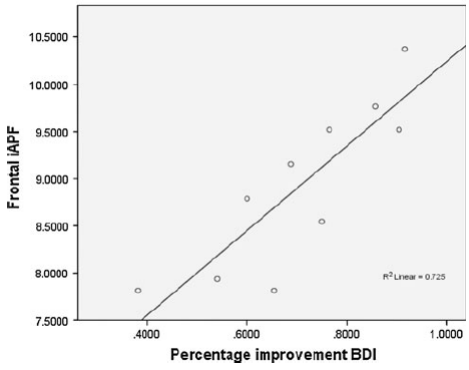
ADHD patients were classified into the following groups based on outtake data:

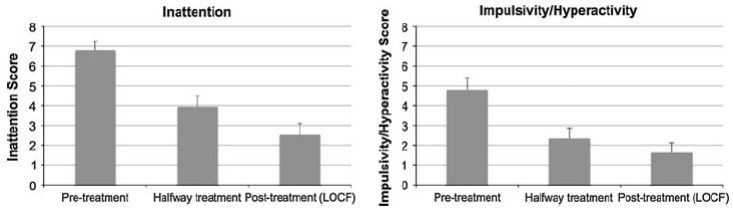
- *Responder (R)*: At least a 50 % reduction on one or both subscales of the ADHD self-report rating scale [ATT or Hyperactivity/Impulsivity (HI)] at outtake.
- *Drop-out (DO)*: When a patient did not take more than 20 sessions and could not be classified a responder. A last observation carried forward (LOCF) procedure was used to handle these data in that the last available scores (at session 10) were used as 'outtake'.
- *Non-responder (NR)*: A patient not meeting criteria for being a 'responder' who finished more than 20 sessions of neurofeedback.

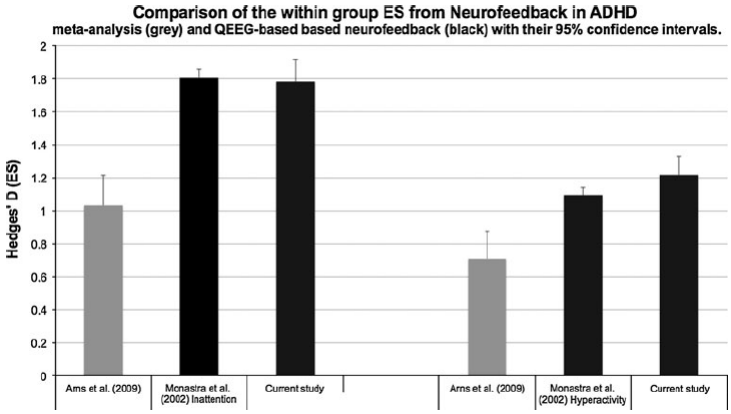
Table 2 Sample characteristics and neurofeedback protocols used in the present study

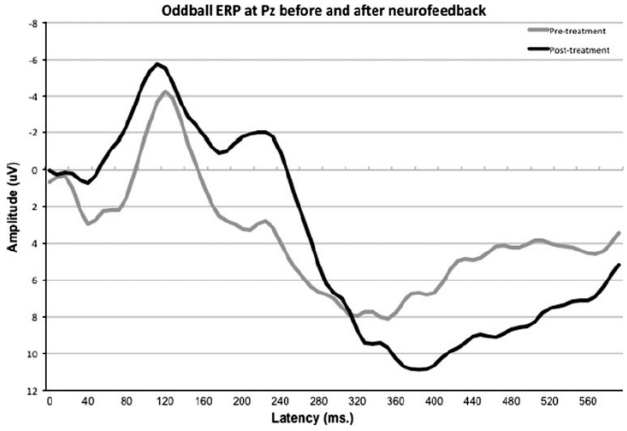
Sample characteristics	
Age	29,95 (SD: 16,19) years
Gender	8 female/13 male
Children/adults	7 children/14 adults
Medicated	9/21
ADD/ADHD	11/10
Number of sessions	33.62 (SD: 16.09)
Neurofeedback protocols	
SMR protocol	15/21
Theta/(beta) protocol	6/21
Beta-downtraining protocol	7/21
Frontal alpha protocol	3/21
Alpha-uptraining protocol	6/21

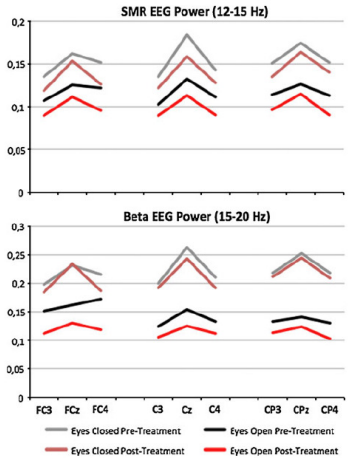


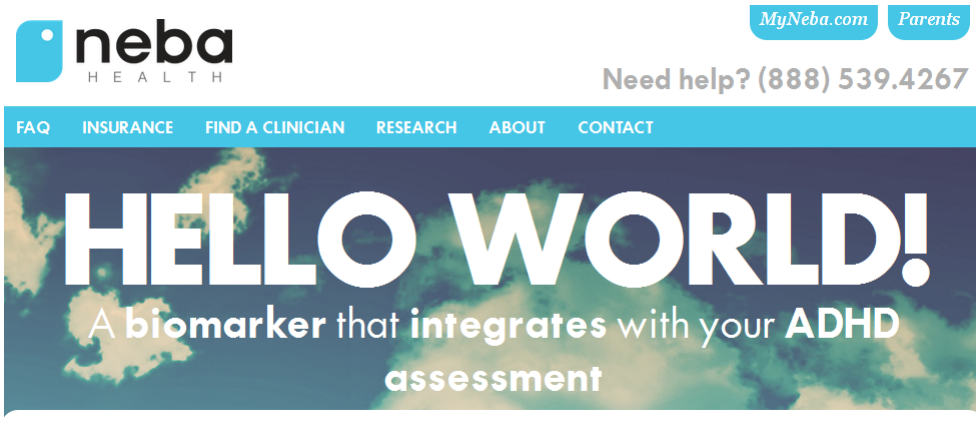












INDICATIONS FOR USE

The Neuropsychiatric EEG-Based ADHD Assessment Aid (NEBA®) uses the theta/beta ratio of the EEG measured at electrode CZ on a patient 6-17 years of age combined with a clinician's evaluation to aid in the diagnosis of ADHD.

NEBA should only be used by a clinician as confirmatory support for a completed clinical evaluation or as support for the clinician's decision to pursue further testing following a clinical evaluation. The device is NOT to be used as a stand-alone in the evaluation or diagnosis of ADHD.

LIMITATIONS

For prescription use only.

The NEBA cannot be used in an individual for whom an EEG recording is not valid, specifically a patient with:

- a history of EEG abnormalities;
- a history of a seizure disorder;
- on anticonvulsant medication(s);
- a metal plate in the head; or
- a metal device in the head.

The NEBA system cannot be used in subjects who are unable to remain still for a minimum of 30 seconds for EEG recording.

The NEBA system should only be used by medical professionals qualified to assess psychiatric disorders and experienced in diagnosing ADHD. To ensure proper device performance, the user must first perform a diagnostic evaluation per the standard of their practice. NEBA interpretations are based on the clinician's initial diagnostic evaluation, the subject's age and the EEG results.

The device should not be used as a stand-alone diagnostic device.

PLEASE REFER TO THE LABELING FOR A MORE COMPLETE LIST OF WARNINGS, PRECAUTIONS AND CONTRAINDICATIONS.

The NAS is stand-alone software which takes in EEG data recorded by the CEEG system, processes it, and produces the final NEBA Report. The NAS consists of EEG artifact reduction and review software, EEG Frequency Analysis and theta-beta ratio calculation software, and the NEBA Report Generator software. Trained technicians first use the NAS to perform manual and algorithm-based artifact reduction of the EEG signal. The artifact-reduced EEG data is then processed using frequency spectrum analysis software, which converts the time-domain EEG data into the frequency domain. Calculations are then performed to determine the ratio of the power of the theta band ([redacted] Hz) to the beta band ([redacted] Hz). Finally, the results of the theta-beta ratio calculations are processed by the NEBA Report Generator to generate the report provided to the clinician.

The high-level NEBA sub-systems form an EEG recording and analysis system that is used to compare an individual's quantified EEG with clinical reference values. NEBA provides clinicians with a specific EEG marker of activity in the form of a power ratio. This ratio is computed by [redacted] Age-adjusted TBR cutoffs are provided that are specific to the NEBA processing and analysis of EEG.

		NEBA Result		
		Low TBR	**Moderate TBR**	**High TBR**
Clinician's ADHD Evaluation	**Positive for ADHD**	*Strongly Recommend Further Clinical Testing. (other conditions)*	*Suggest Further Clinical Testing. (other conditions)*	*Confirmatory Support for ADHD as primary diagnosis*
	Uncertain for ADHD	*Strongly Recommend Further Clinical Testing. (other conditions)*	*Suggest Further Clinical Testing. (other conditions)*	*Suggest Further Clinical Testing. (ADHD)*
	Negative for ADHD	*Negative for ADHD as primary diagnosis*	*Negative for ADHD as primary diagnosis*	*Negative for ADHD as primary diagnosis*

NEBA cutoffs for analysis were pre-established in a separate study and are different for adolescents (aged 12.00 – 17.99 years) and children (aged 6.00 – 11.99 years):

About NEBA

NEBA is a 15 minute test that integrates an EEG biomarker for ADHD into the clinical setting. NEBA can help the clinician verify when ADHD is present. In series with a clinician's standard workup, NEBA helps confirm ADHD. NEBA also helps clinicians determine whether ADHD-like symptoms are due to another condition. Study results showed that NEBA could reduce over-diagnosis of ADHD to as low as 3%.

When applying NEBA, clinicians still conduct their regular evaluation. NEBA provides additional information by using EEG to separate ADHD patients into biomarker-based groups with clinical differences that allow validated recommendations to be offered to the clinicians. NEBA is the only ADHD biomarker that is FDA cleared, CE marked, Health Canada licensed, and USPTO patented.

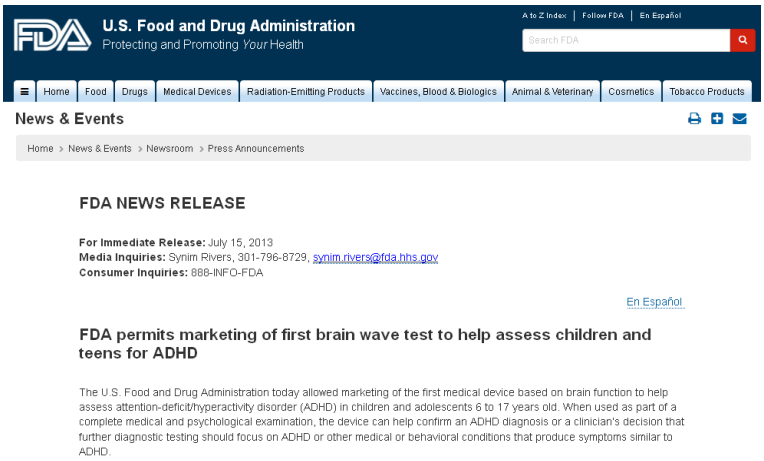
- FDA.gov: FDA permits marketing of first brain wave test to help assess children and teens for ADHD.
- Time.com: FDA approves first scan for ADHD.
- New York Times: Brain test to diagnose ADHD is approved.
- MSNBC / The Grio: New screening tool for ADHD.
- Science: FDA approves first medical device for ADHD diagnosis.
- Psychology Today: Diagnosing ADHD by brainwaves?
- Psychology Today: To test or not to test?
- Inc Magazine: The tiny startup behind the brainwave test for ADHD.
- CBS 5 Phoenix: New Test Approved by FDA.
- Dr. Arif Mirza explains NEBA - Channel 24 - ABC Memphis.
- New ADHD test a 'breakthrough,' say medical experts
- FDA creates new classification rule for NIEAs

AUGUSTA, GA (July 22, 2013) – NEBA Health, LLC releases today key study results regarding the FDA approval of NEBA®, the first brain wave test to help clinicians assess ADHD in children and adolescents.

About NEBA

NEBA integrates an ADHD biomarker together with a clinician's ADHD evaluation. In other words, NEBA is not used as a stand-alone diagnostic. The clinician still conducts their ADHD evaluation as in their regular practice using their usual assessment tools. Once the clinician determines that ADHD-like symptoms are present, NEBA helps the clinician to determine whether the symptoms are due to ADHD, or due to another condition. NEBA does this using EEG to separate ADHD patients into biomarker-based groups with clinical differences that allow validated recommendations to be offered to the clinicians.

Because ADHD symptoms overlap with other diagnoses, there may be difficulty for the clinician to determine whether ADHD is the primary cause, whether ADHD symptoms are secondary to other diagnoses, or whether ADHD is comorbid with other diagnoses. Dr. Steve Snyder, Vice President of Research and Development said, "NEBA can help the clinician to confirm ADHD as primary diagnosis, and can help the clinician to determine whether ADHD-like symptoms may be better explained by another primary condition. "



The device, the Neuropsychiatric EEG-Based Assessment Aid (NEBA) System, is based on electroencephalogram (EEG) technology, which records different kinds of electrical impulses (waves) given off by neurons (nerve cells) in the brain and the number of times (frequency) the impulses are given off each second.

The NEBA System is a 15- to 20-minute non-invasive test that calculates the ratio of two standard brain wave frequencies, known as theta and beta waves. The theta/beta ratio has been shown to be higher in children and adolescents with ADHD than in children without it.

Table 1. Results support that a diagnosis rendered by a clinician using NEBA would be more likely to converge upon the diagnostic results of a multidisciplinary team (MDT).

	Clinician	95% CI - low	95% CI - high	n	Clinician + NEBA	95% CI - low	95% CI - high	n
specificity (%)	36	29	44	145	94	89	97	145
sensitivity (%)	89	83	93	130	82	74	87	130
positive predictive value (%)	56	49	62	209	92	86	96	115
negative predictive value (%)	79	67	87	66	85	79	90	160
overall accuracy (%)	61	55	67	275	88	84	91	275

Bringing Frontal / Mood into the equation

- Frontal asymmetry associated with mood
- Davidson, Rosenfeld, Baehr
- Left = “positive”
- Right = “negative”
- Past work used alpha asymmetry
- New work is using gamma
- Not trait only – now looking at state responses to stimuli
- Incorporation of decision-making model

New Methods

- Use of Gamma (activation) rather than Alpha (relaxation)
- Use of sLORETA (brodmann, ROI) rather than surface
- Note that many frontal dipoles are lateral (parallel to surface)
- Use of event-related paradigms
- Separation of state and trait characteristics
- Development of emotional and ethical decision-making methods

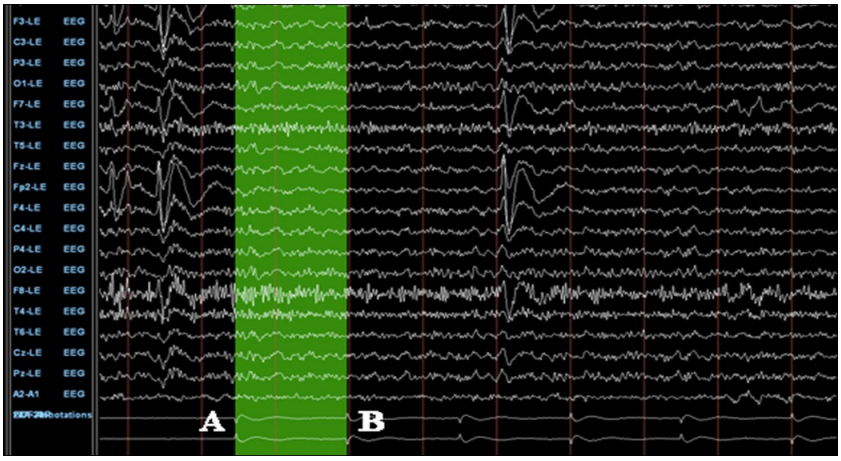
Toward an Operational Model of Decision Making, Emotional Regulation, and Mental Health Impact

Thomas F. Collura, PhD, QEEG-D, BCN, LPC; Carlos P. Zalaquett, PhD, LMHC; Ronald J. Bonnstetter, PhD; Seria J Chatters, PhD

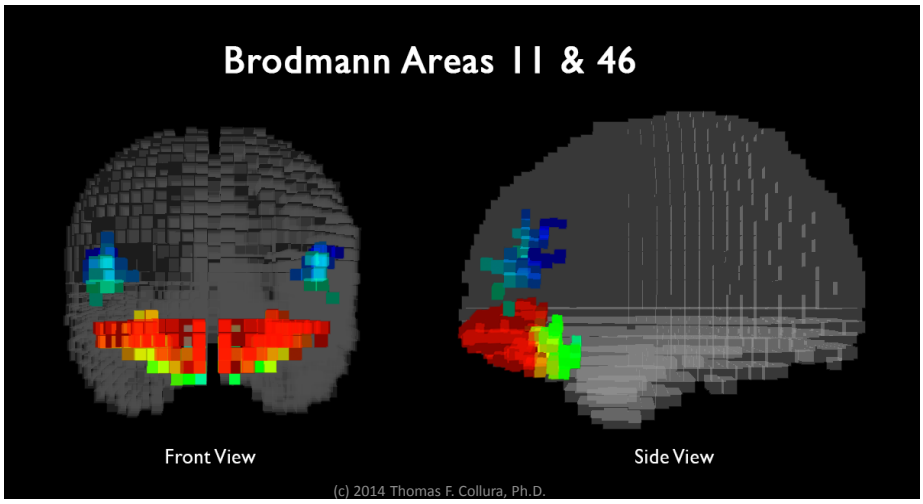
ABSTRACT

Current brain research increasingly reveals the underlying mechanisms and processes of human behavior, cognition, and emotion. In addition to being of interest to a wide range of scientists, educators, and professionals, as well as laypeople, brain-based models are of particular value in a clinical setting. Psychiatrists, psychologists, counselors, and other mental health professionals are in need of operational models that integrate recent findings in the physical, cognitive, and emotional domains, and offer a common language for interdisciplinary understanding and communication. Based on individual traits, predispositions, and responses to stimuli, we can begin to identify emotional and behavioral pathways and mental processing patterns. The purpose of this article is to present a brain-path activation model to understand individual differences in decision making and psychopathology. The first section discusses the role of frontal lobe electroencephalography (EEG) asymmetry, summarizes state- and trait-based models of decision making, and provides a more complex analysis that supplements the traditional simple left-right brain model. Key components of the new model are the introduction of right hemisphere parallel and left hemisphere serial scanning in rendering decisions, and the proposition of pathways that incorporate both past experiences as well as future implications into the decision process. Main attributes of each decision-making mechanism are provided. The second section applies the model within the realm of clinical mental health as a tool to understand specific human behavior and pathology. Applications include general and chronic anxiety, depression, paranoia, risk taking, and the pathways employed when well-functioning operational integration is observed. Finally, specific applications such as meditation and mindfulness are offered to facilitate positive functioning.(*Adv Mind Body Med.* 2014;28(4):18-33.)

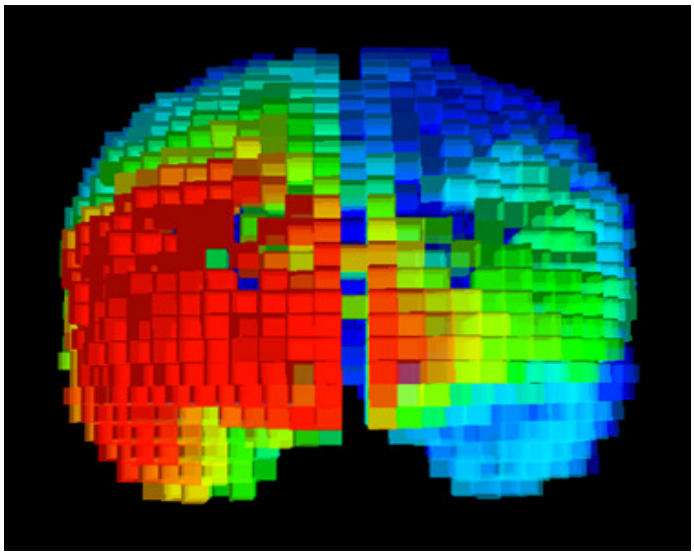
Event-Related EEG Imaging

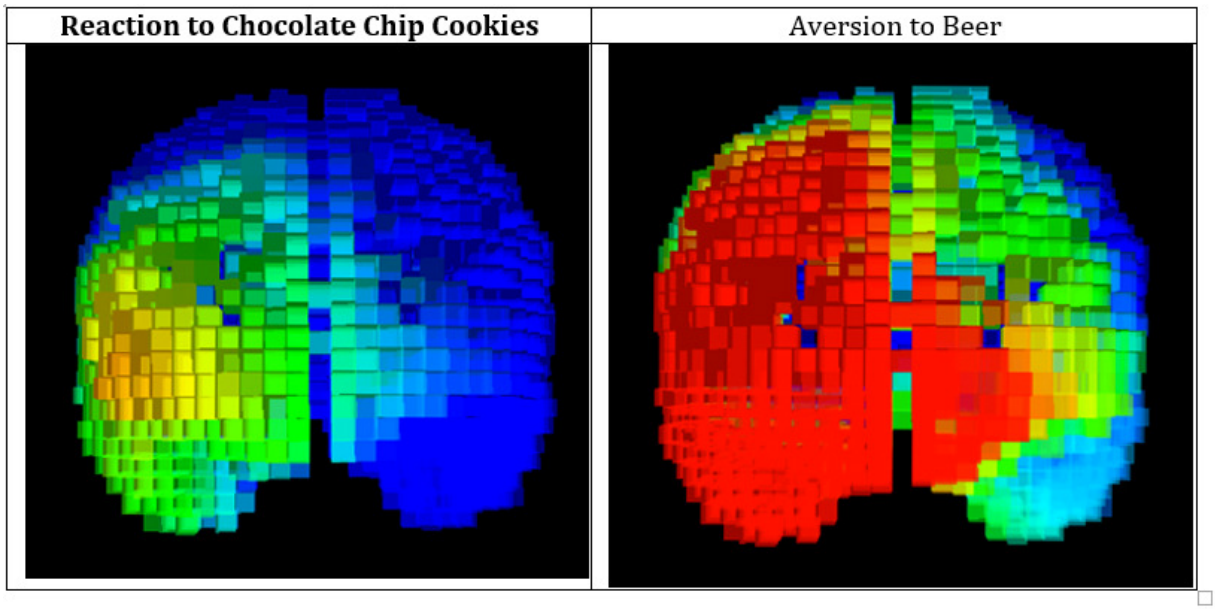


Key emotional regulatory centers
primary and secondary emotional response
Emotional sensation -> emotional perception



Baseline Mood State Depressed

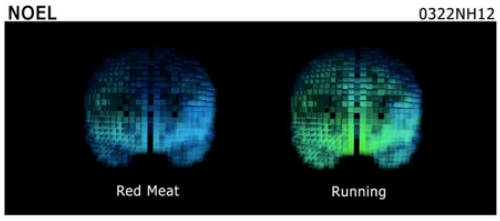


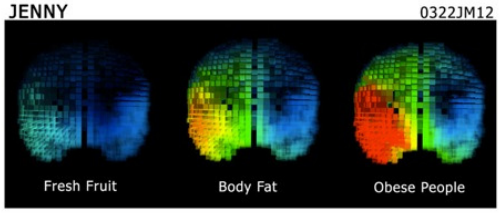


TTI Research & Development

Physical Health Assessment

Initial Results





Left-Right Functionality

Mechanism	Parallel	Serial
Hemisphere	Right	Left
Data Representation	Holographic	Sequential
Perspective	Visuo-spatial	Temporo-linguistic
Analogous to	Pictures	Music, speech
Context	Global (this always…)	Local (in this particular case,…)
Orientation	Patterns	Lists
Tasking	Multitasking (may be stressful)	Single-tasking (focused, calm)
Perspective	Past	Future
Dimension	Space	Time
Attribute	Patterns (spatial)	Causality
Memory	Past patterns, "punishment"	Cause/effect experiences, rules
Mode of analysis	"the last time…"	"what if…"
Result	Avoid / Attack	Approach / Remain

Left-Right Mood Regulation

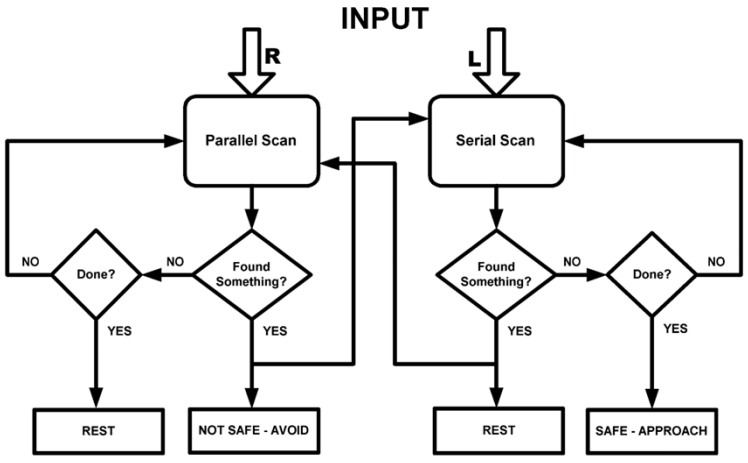
Emotion	Negative	Positive
Decision cycle	1 analysis	Sequence of n analyses
Activation sequence	1 "found"	N "not founds" then done
Priority	Detecting danger	Ensuring safety
Decision priority	Immediate	Long-term
Approach	Tactical, here & now	Strategic, future outcomes
Equation parameters	Pp+=1, Ppf=1	Ps+=1, Psf=1
Associated behaviors	Run; fight	Breathe; build
Neurotransmitter	Adrenalin	Serotonin

Mesial – Dorsolateral distinction

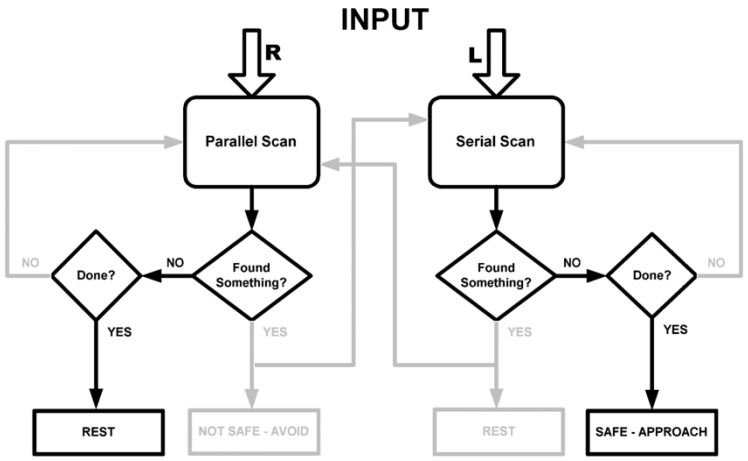
- Mesial – primary emotional sensation
  - Fundamental, initial sense –"nice" or "not nice"
- Dorsolateral – seconday emotional perception
  - Integrated with memory
  - Put into context
  - Can turn interpretation "around"

Emotional Decision Making Model

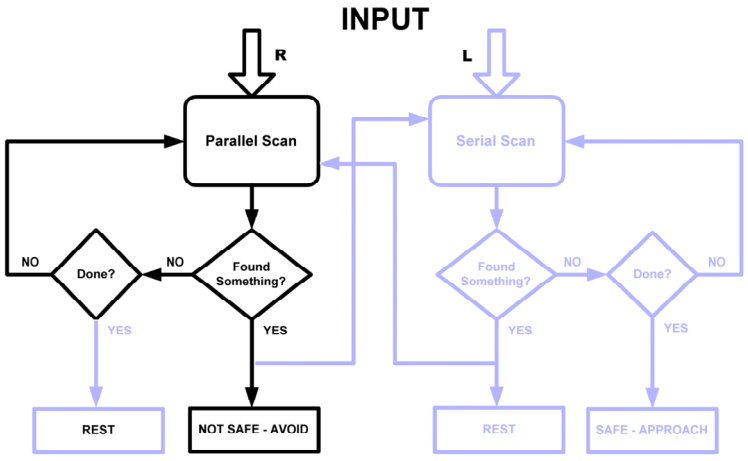
(why we downtrain alpha on the left dorsolateral frontal lobe)



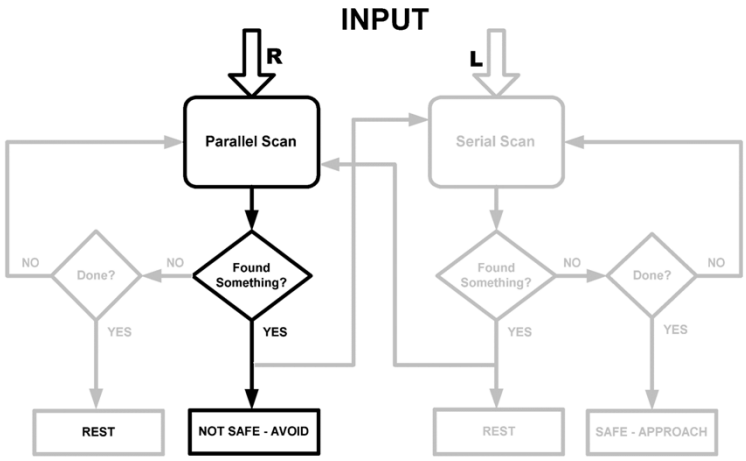
Happiness as a process



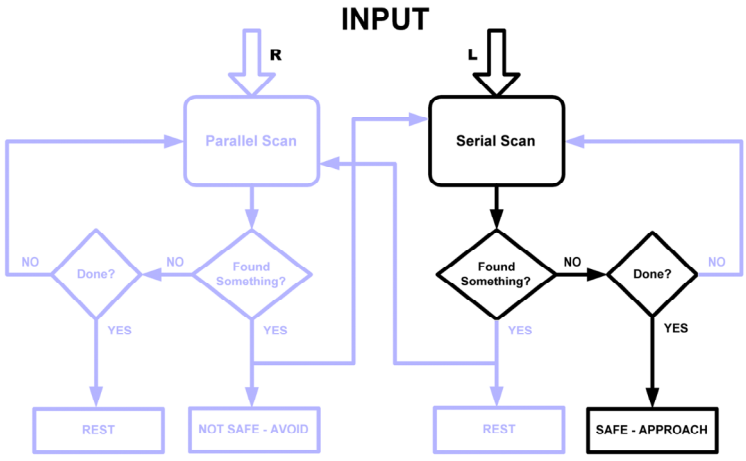
Depressed



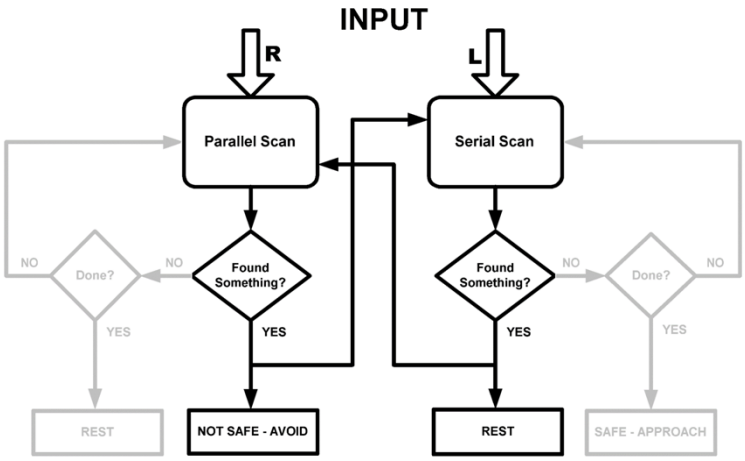
Paranoid



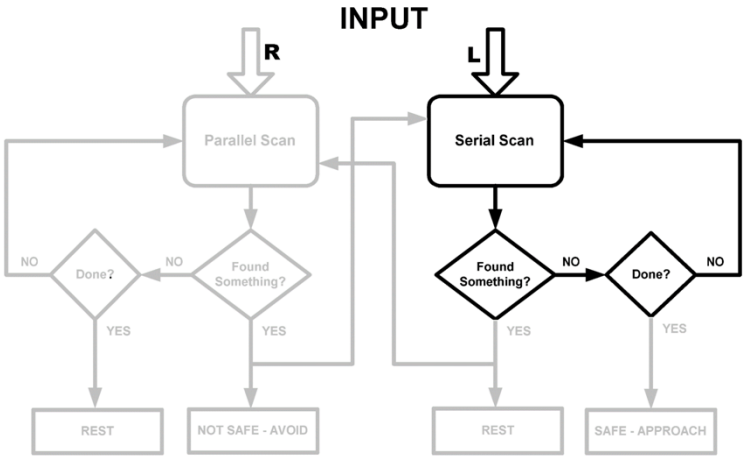
Risktaker



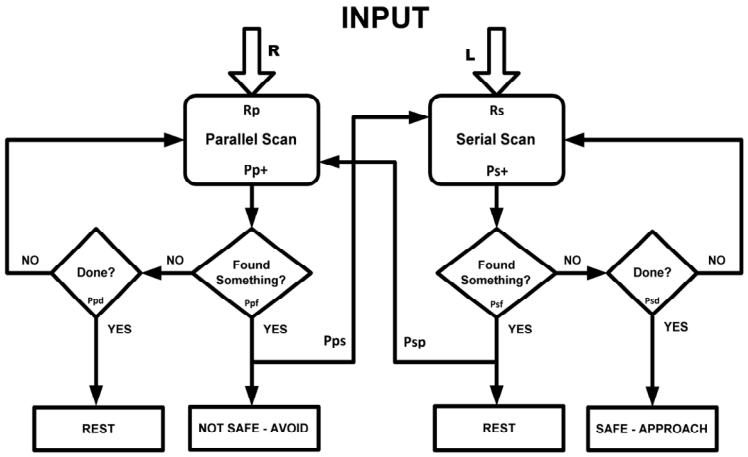
Chronic Anxiety



General Anxiety



Quantitative Model

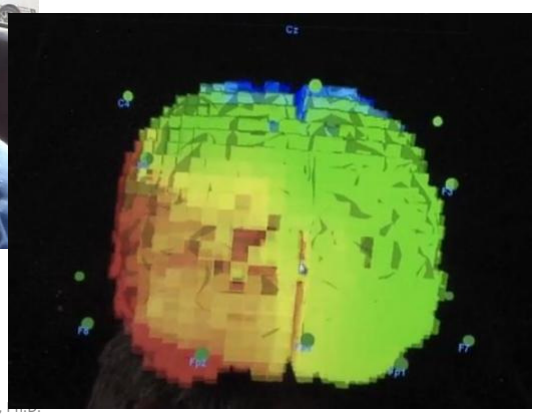


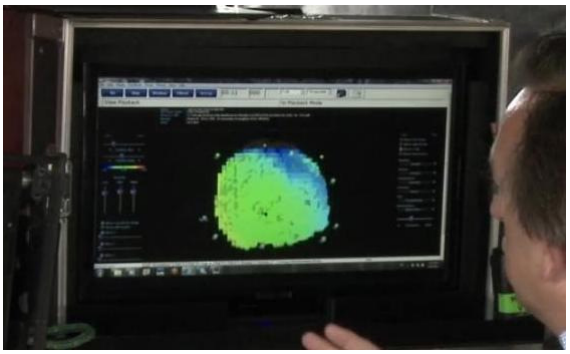
Use of characteristic qualitative/quantitative types

Emotion Vector	EV = (Rp, Pp+, Ppf, Ppd, Pps, Rs, Ps+, Psf, Psd, Psp)									
Rp	Rate of parallel processing: patterns/second enters primary emotional sensation									
Pp+	Probability that parallel processing will pass information on to secondary processing									
Ppf	Probability that parallel processing with return "found" based on importance level of input									
Ppd	Probability that parallel processing will return "done" after processing a pattern									
Pps	Probability that parallel processing will pass finding on to serial processing if "found"									
Rs	Rate of serial processing: scans/second enters primary emotional sensation									
Ps+	Probability that serial processing will pass information on to secondary processing									
Psf	Probability that serial processing with return "found" based on importance level of input									
Psd	Probability that serial processing will return "done" after processing a pattern									
Psp	Probability that serial processing will pass finding on to parallel processing if "found"									
Examples	Rp	Pp+	Ppf	Ppd	Pps	Rs	Ps+	Psf	Psd	Psp
Happy	1	1	0	1	1	1	1	0	1	1
Paranoid	1	1	1	0	0	0	0	0	0	0
Anxious	1	1	1	0	1	1	1	1	0	1
trauma	+	+	+							

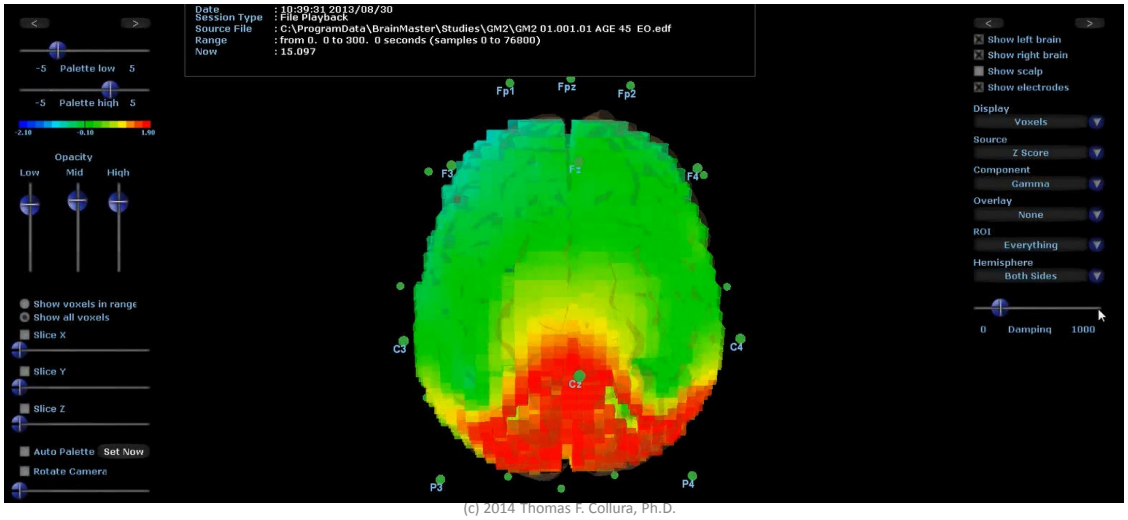
Examples (videos will be shown)

- Professional (Precision) Driver
- Professional (Endurance) Driver
- Novice Driver

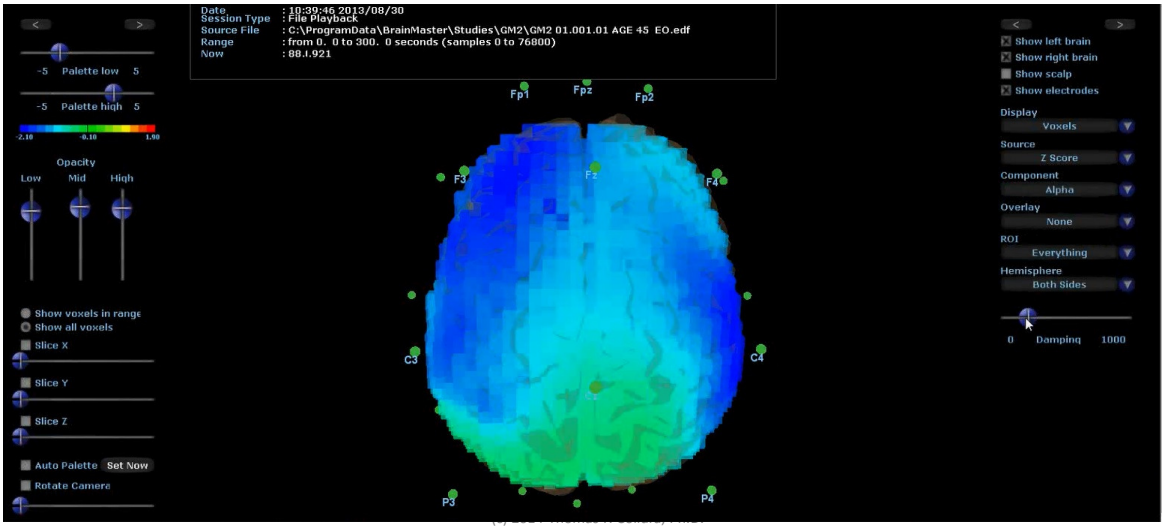




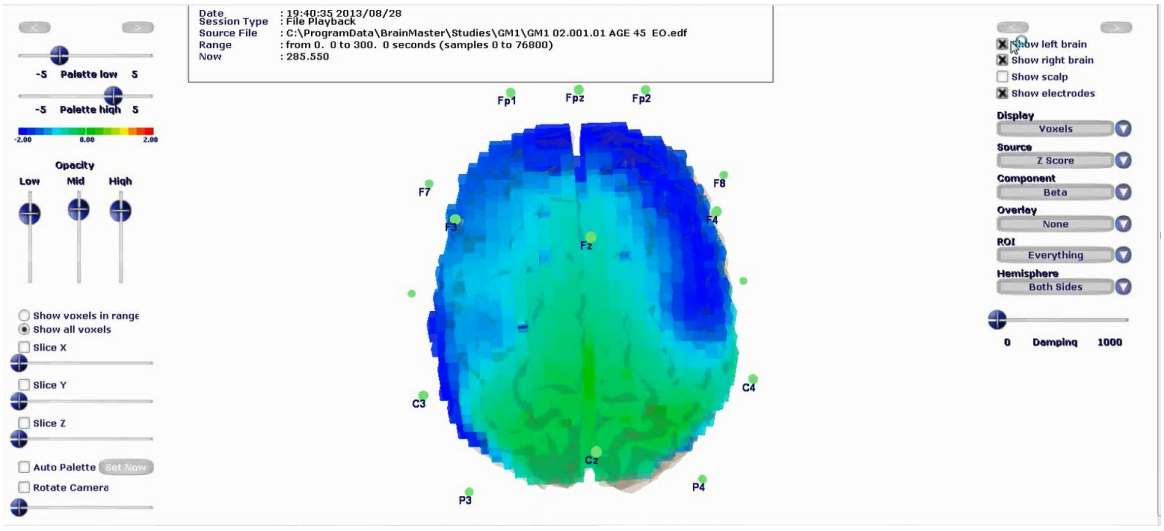
Evan – scanning alert



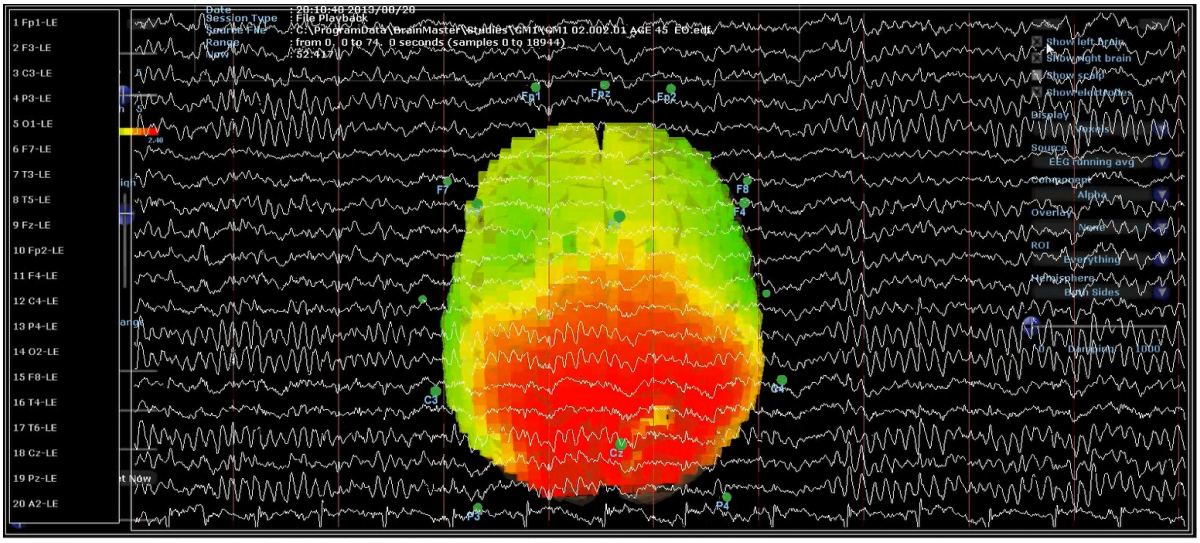
Evan – not relaxed



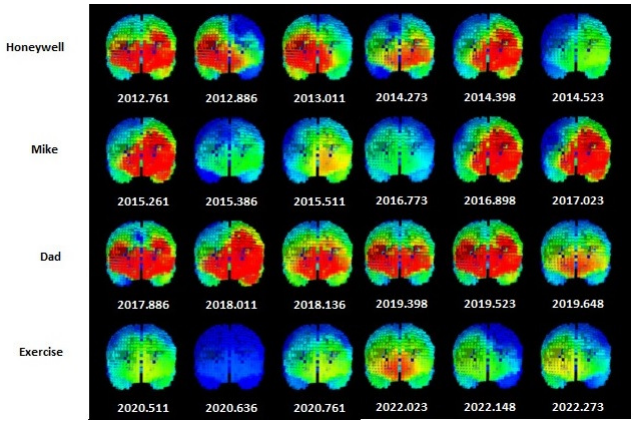
Craig – on automatic



Craig - Relaxed



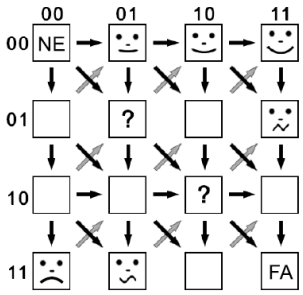
Forensic Emotional Imaging



Emotional Transition Model

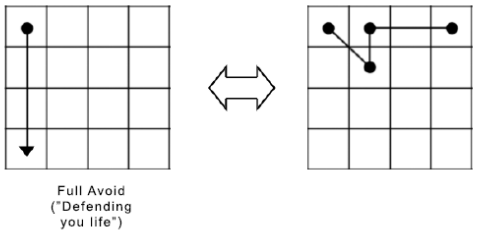
Rs Rp Ls Lp TOM'S NOTES - Page 1

0000 - non-engaged
0001 - feels good
0010 - happy-risk taking
0011- happy now + safe
0100 - feels bad
0101 - mixed feel
0110 - feels bad but might be ok
0111 - happy inspite of neg. feel
1000 - looking for danger
1001 -
1010 - mixed judgement
1011 -
1100 - avoid full
1101 - negative inspite of + feel
1110 -
1111 - full alert

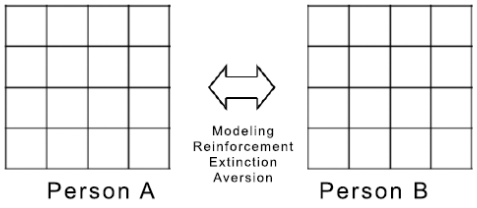


Crystals in time
easier to remember bad experiences
build up in time need to mix +, - start with Davidson Q&A as age, more (-)'s can pile up.

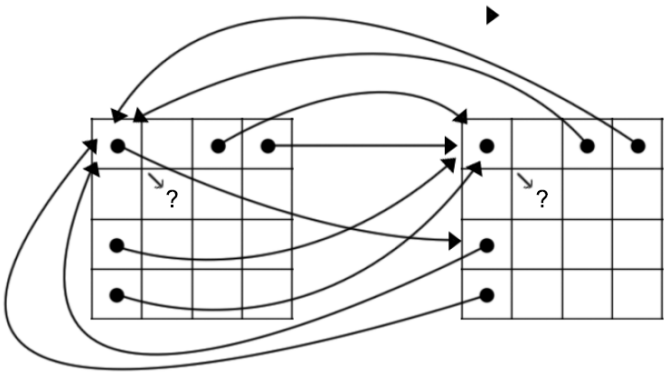
Patterns & Interactions



Full Avoid
("Defending you life")



HAIDT'S SOCIAL INITIATIVE MODEL



Modeling, how counselor reacts will shape client response patter, reframe, challenge, reflect, etc.

EMOTIONAL DECISION MODEL
EDM-2
4 COMPONENTS - S4

Rs Rp \ Ls Lp	00	01	10	11
00	NOT ACTIVATED 0000	PRIMARY + PLEASURE "Like" 0001	SECONDARY + SAFE "Good" 0010	FULL + APPROACH "Like+Good" 0011
01	PRIMARY - "Don't Like" UNPLEASANT 0100	PRIMARY +&- "Suspend Feeling" 0101	PRIMARY+ SECONDARY+ "Don't Like"" + "Good" (DIETING) 0110	PRIMARY+ &- SECONDARY+ + "Mixed Feling" + "Good" FOLLOW HEAD 0111
10	SECONDARY - "Not Good" UNSAFE 1000	PRIMARY+ SECONDARY+ "Like"" + "Not Good" (NAUGHTY) 1001	SECONDARY +&- "Suspend Judgement" 1010	PRIMARY+ &- SECONDARY+ + "Like" + "Mixed Judgement" FOLLOW HEART 1011
11	FULL + "Don't Like" + "Not Good" AVOID 1100	PRIMARY+ &- SECONDARY+ + "Not Like" + "Not Good" FOLLOW HEAD 1101	PRIMARY+ &- SECONDARY+ + "Don't Like" + "Mixed Judgement" FOLLOW HEART 1110	FULL ACTIVATED +&- 1111

Insights

- It takes more work to be positive than to be negative
- Specific emotional/cognitive skills necessary for healthy mood
- Balance of negativity an positivity is essential for effective functioning
- Specific deviations associated with particular emotional/behavioral styles
- Response to stimuli as important (more important) than resting state
- Model for client-clinician interaction, other interactions

New Hardware / Software

Emotional Decision-Making App

Summary

- Dynamical model of mood regulation and emotional decision-making
- Multicomponent model, distributed functions
- Identification of specific excesses/deficits
- Activation / deactivation
- Connectivity / isolation
- Correlation with EEG parameters, power, connectivity
- Methods for assessment, treatment, treatment effectiveness
- Recognition of trait and state individuality