Emotional and Cognitive Decision-Making Modeled using EEG Imaging

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Southeast Biofeedback and Clinical Neuroscience Association
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Description

- This workshop will present current results using an EEG-based activation model that takes advantage of sLORETA imaging of frontal regions of interest, in combination with a structured stimulus and analysis procedure. We will present event-related brain activation data from a range of participants and situations including nonclinical, clinical, and forensic populations. The results illustrate instantaneous patterns of frontal activation that are indicative of individual emotional and decision-making patterns.

Objectives

- Recognize EEG patterns associated with specific emotional responses and states.
- Explain how the frontal cortex participates in the creation of emotional responses to stimuli.
- Describe the brain locations involved in positive and negative emotional responses in normal processes.
- Describe aberrations in normal brain processing, that can lead to abnormal emotional responses or states.
- Explain how different interventions have differing effects on the dynamic control of emotion.

Background

- 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

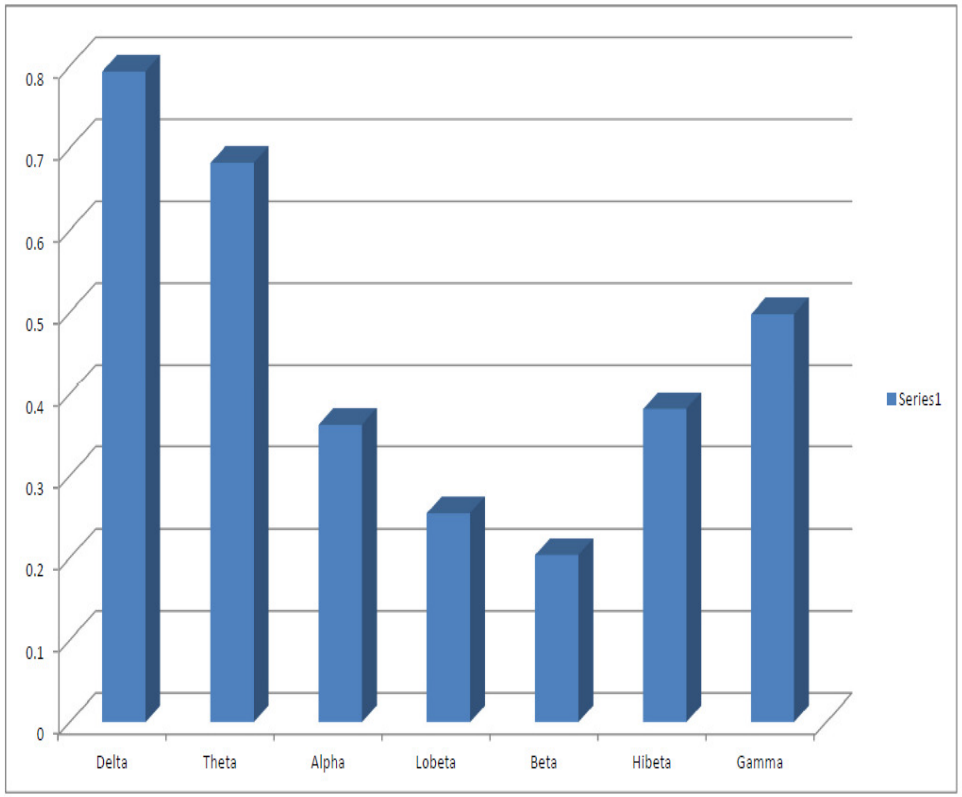
- Use of Gamma (activation) rather than Alpha (relaxation)
- Use of sLORETA (brodmann, ROI) rather than surface
- Note that many frontal dipoles are lateral (parallel to surface)
- Use of event-related paradigms
- Separation of state and trait characteristics
- Development of emotional and ethical decision-making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

ISF Correlation Coefficients-ISF Signal

Correlation Coefficients between ISF (0.002 – 0.05) and conventional band magnitudes

100 seconds of data sampled 8 times/second

Left Parietal area using sLORETA ROI estimation



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

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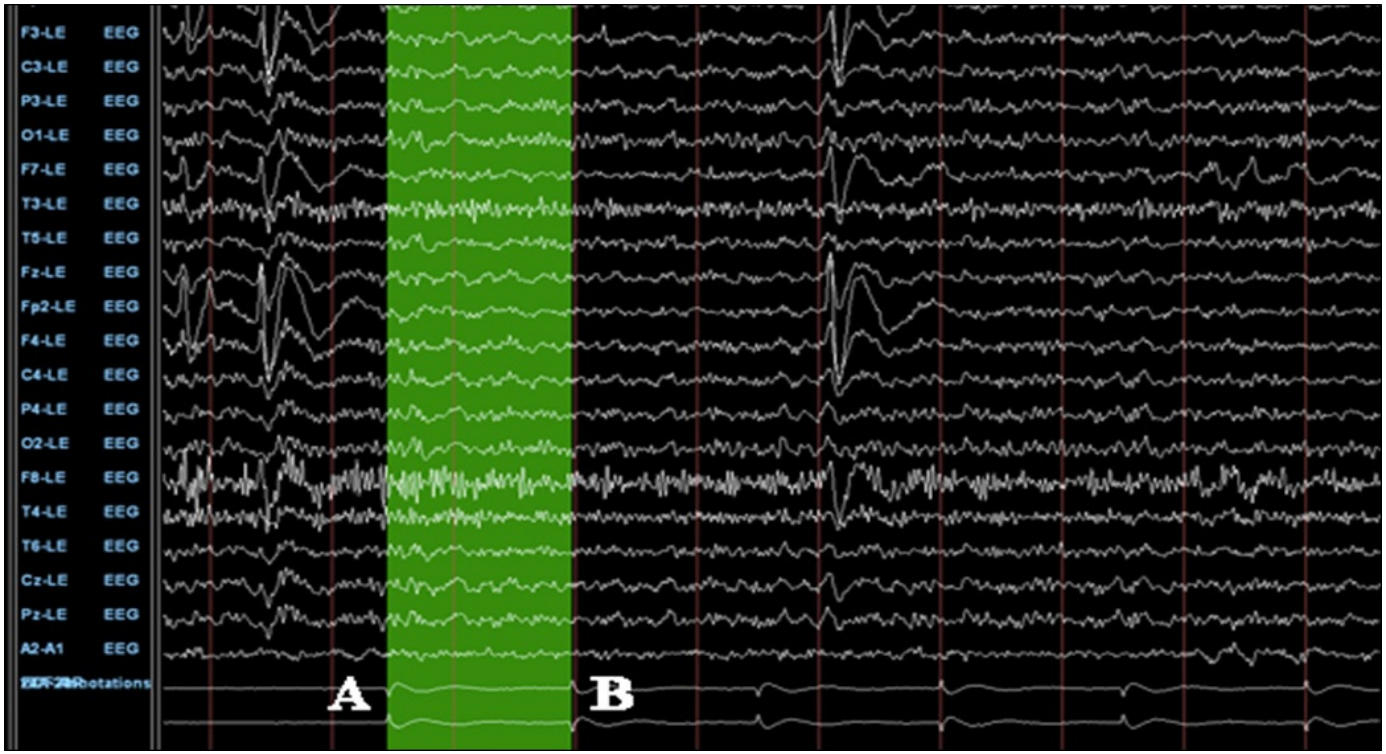
Ronald J. Bonnstetter, PhD; Seria J Chatters, PhD

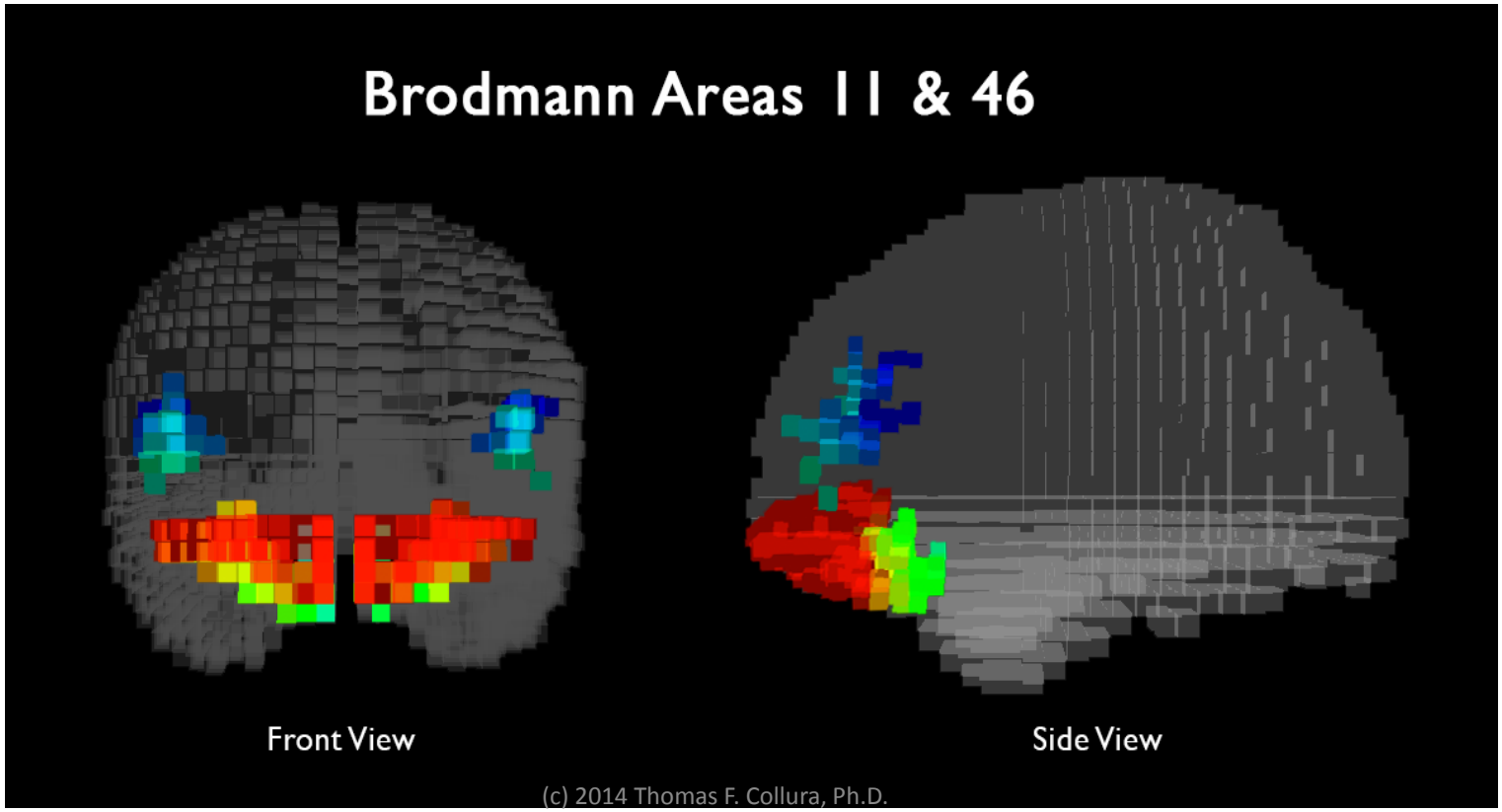
ABSTRACT

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



Emotional Response to Stimuli

A relative balance in **beta** and **gamma** waves creating asymmetry in the activity in the frontal lobes is associated with normal mood and emotional state. Increased activity within the left prefrontal cortex can indicate an elevation in mood and positive feelings. De-activation in the left prefrontal cortex alone or in combination with an increase in activity within the right prefrontal cortex can suggest the opposite, being associated with depressive mood or negative thoughts. Instances in which only the right prefrontal cortex activates quickly with an strong increase in gamma waves suggest a strong dislike or avoidance of a particular exposure.

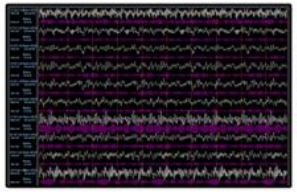
Example Images:

These example images depict the amount of gamma activity present in subjects frontal lobes as they are exposed to different stimuli invoking neutral, positive, and negative responses.

Raw EEG and event markers

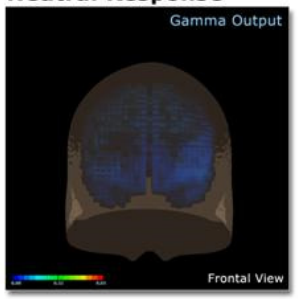
The event stimuli being reviewed in this case is:
"A lover's embrace."

*Each event marker represents a single stimuli.

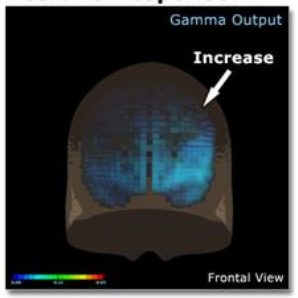


Aquired EEG:
An increase in both beta and gamma waves can be seen when also inspecting the aquired EEG of the event.

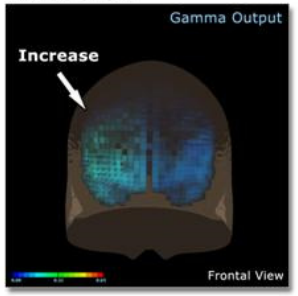
Neutral Response



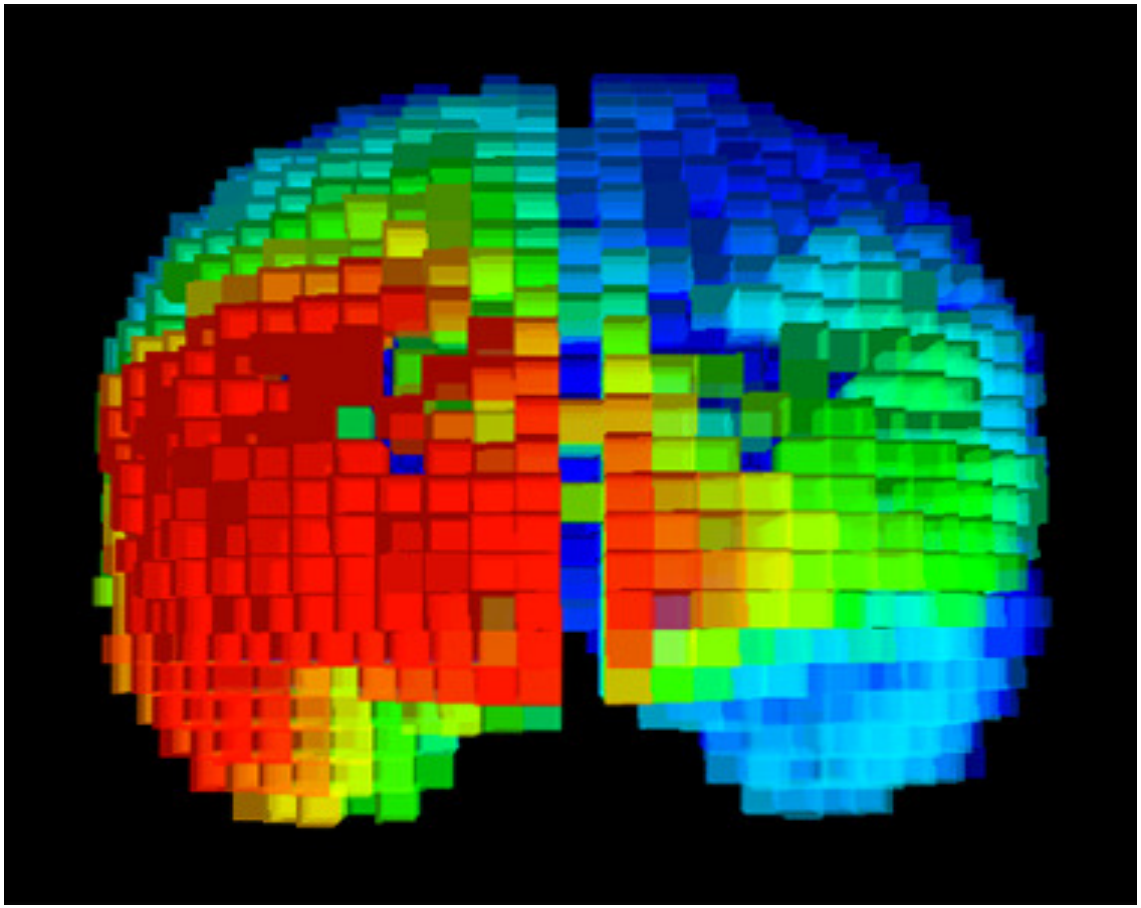
Positive Response

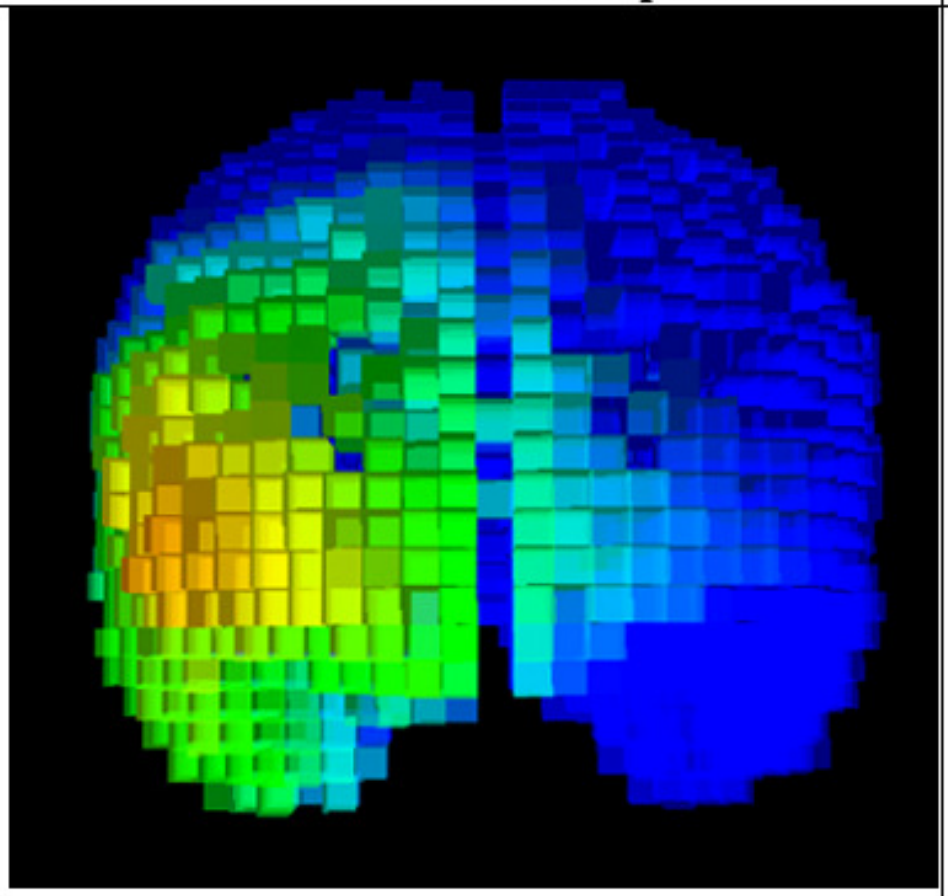
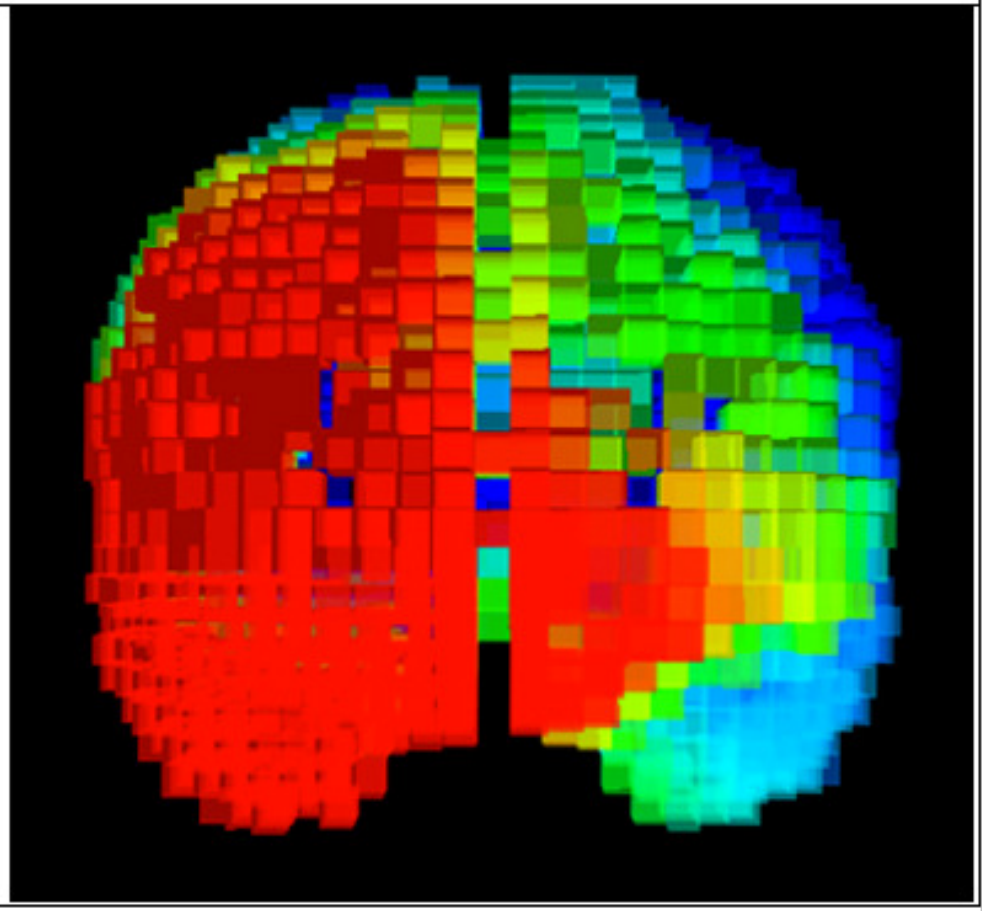


Avoidance



Baseline Mood State Depressed



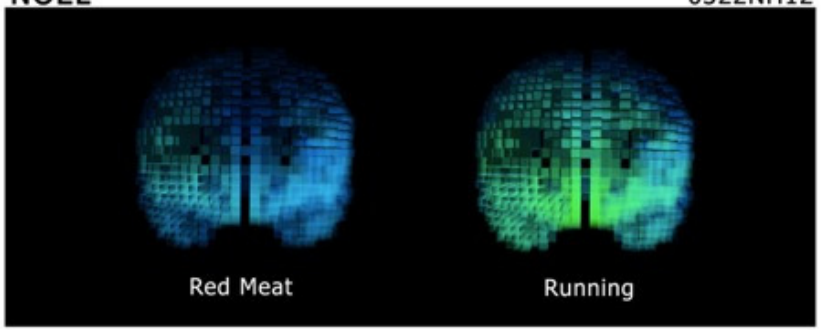
Reaction to Chocolate Chip Cookies	Aversion to Beer
	

TTI Research & Development

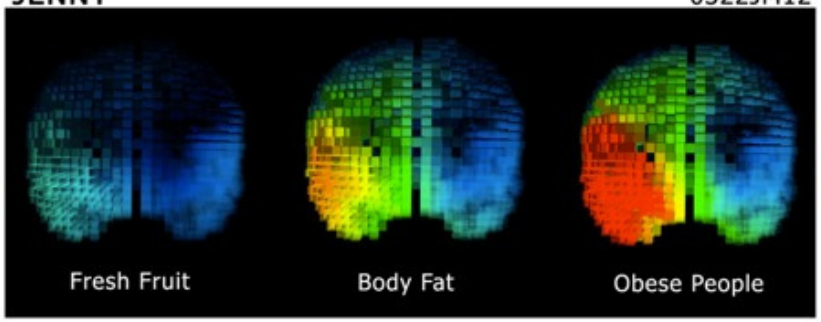
Physical Health Assessment

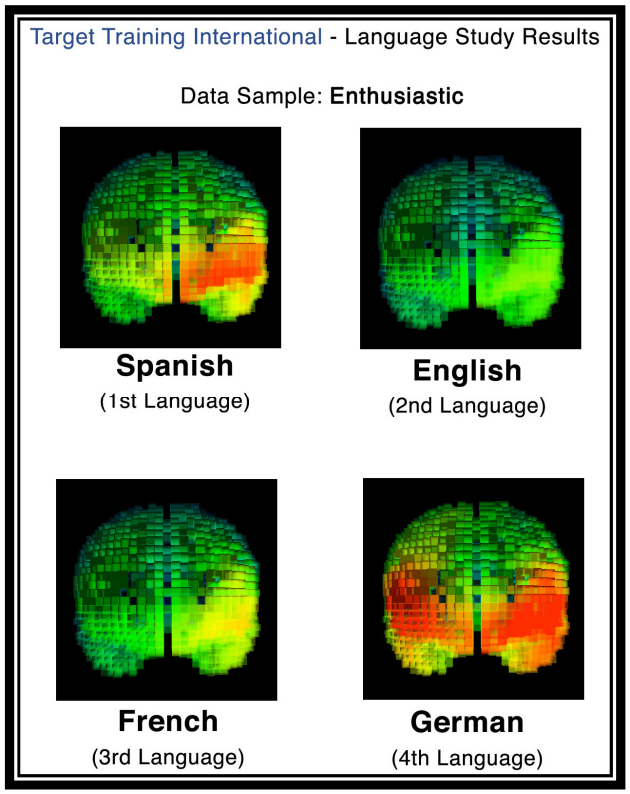
Initial Results

NOEL 0322NH12



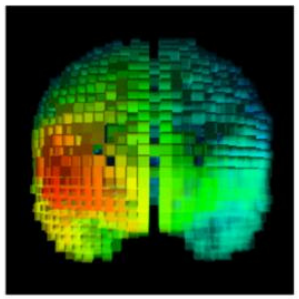
JENNY 0322JM12



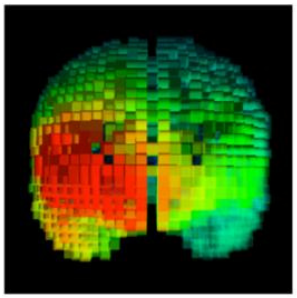


Target Training International - Wellness Study Results

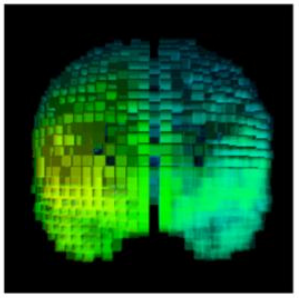
Select questions from depression section



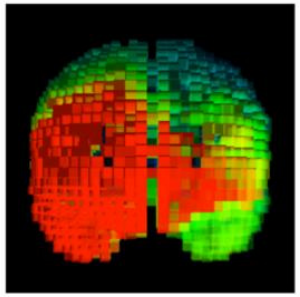
Sleep



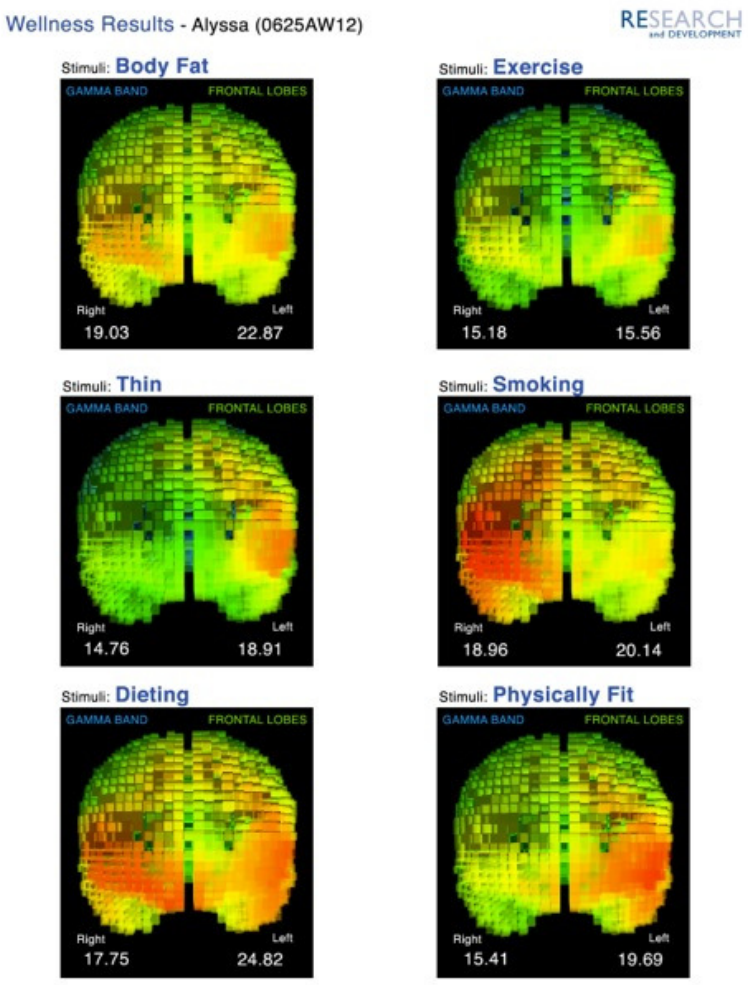
Deep Fried Foods

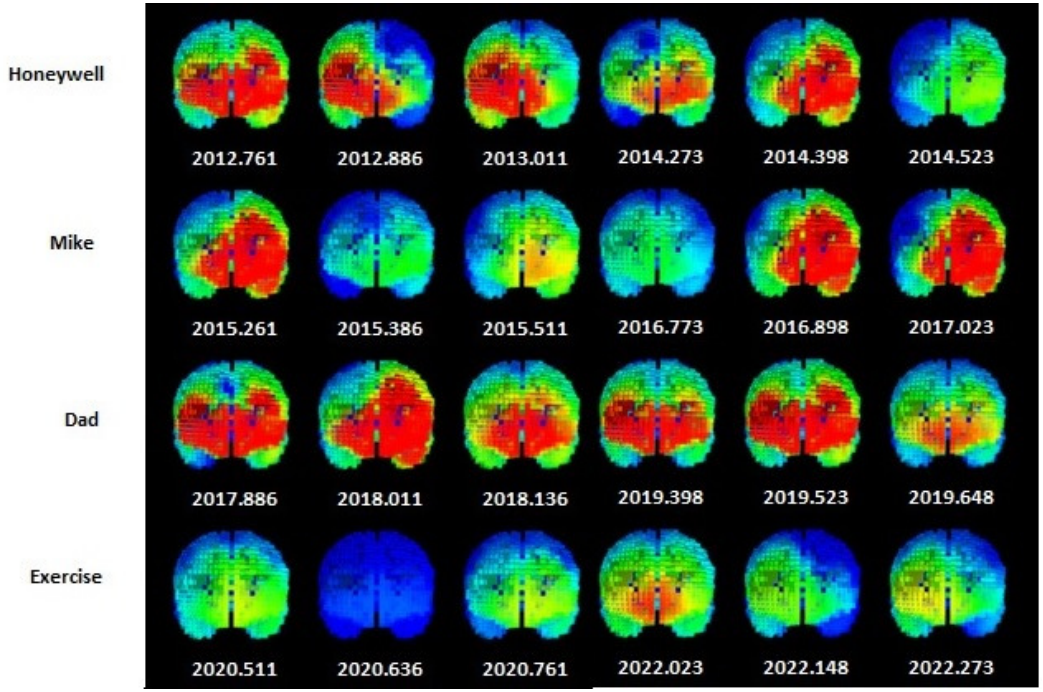


Chocolate Chip Cookies

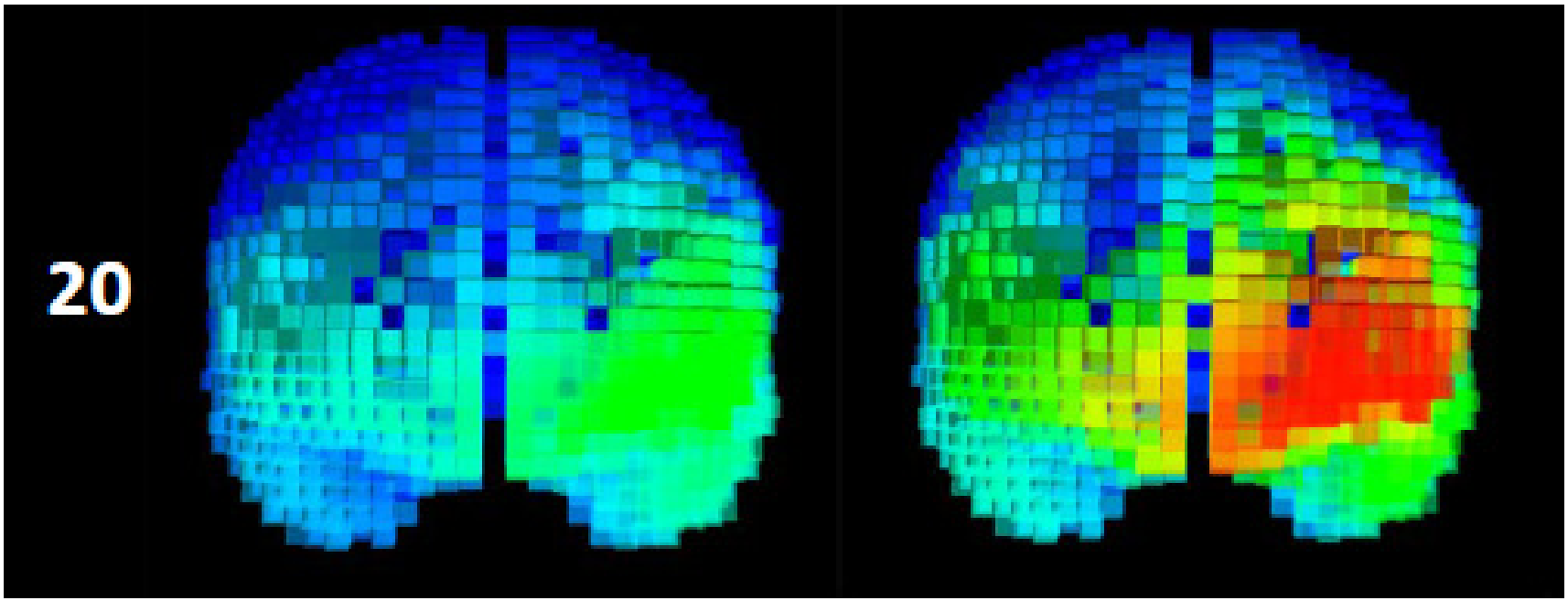


Smoking

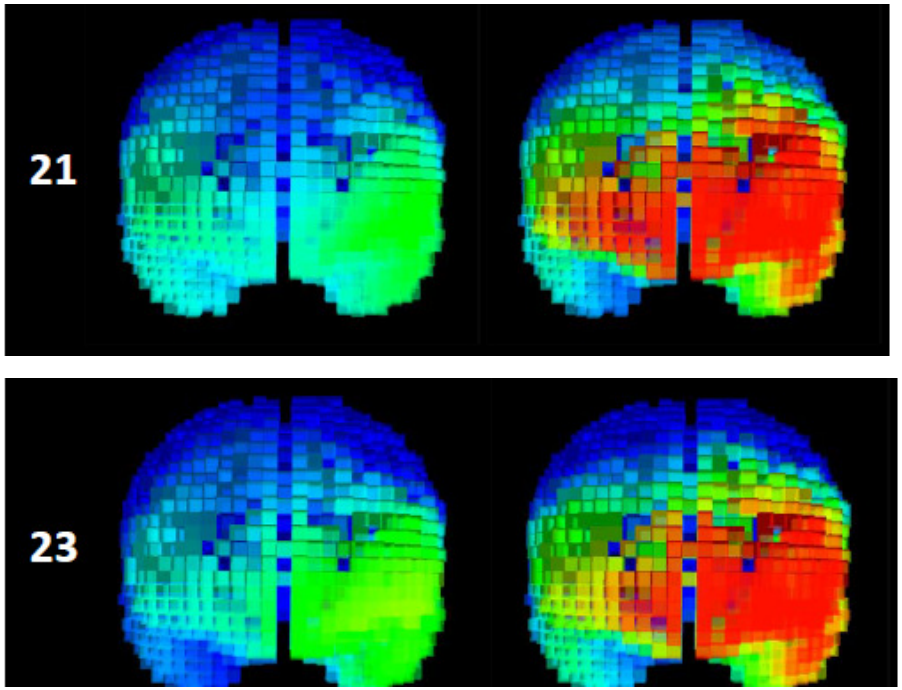




Response to “Dogs”



Gardening and Guns



Gardening

Glock

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

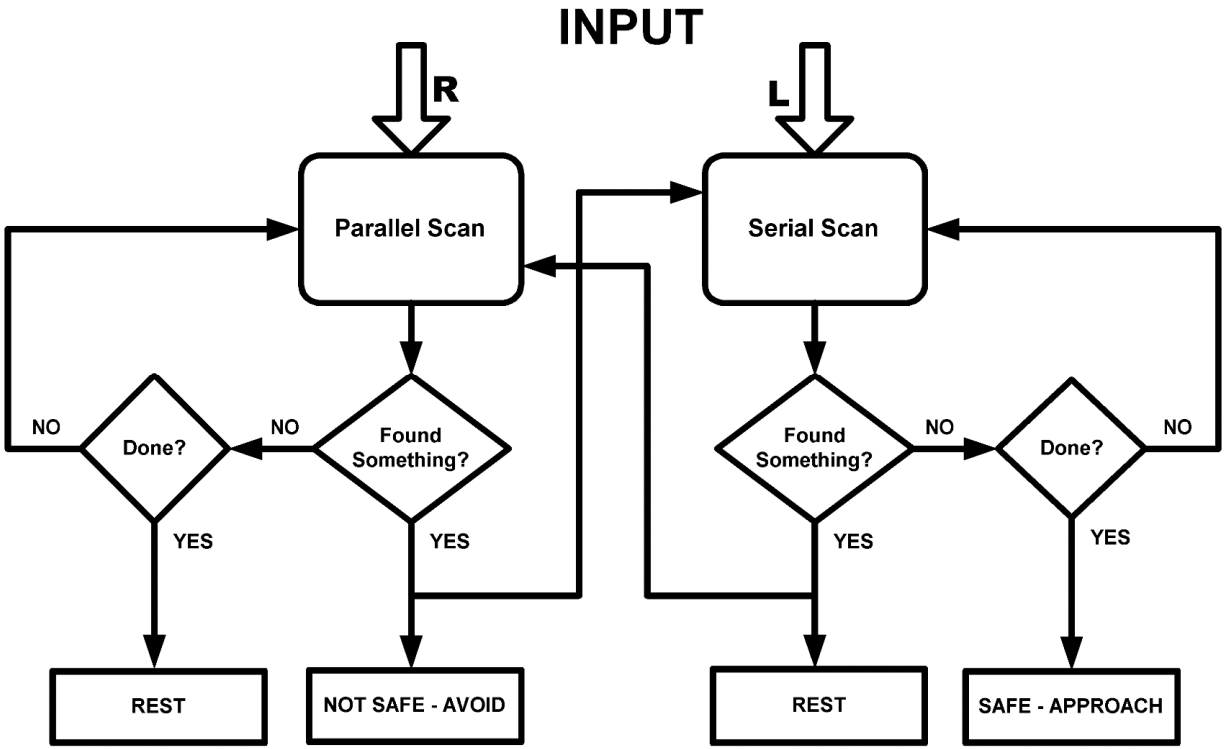
Emotion	Negative	Positive
Decision cycle	1 analysis	Sequence of n analyses
Activation sequence	1 “found”	N “not founds” then done
Priority	Detecting danger	Ensuring safety
Decision priority	Immediate	Long-term
Approach	Tactical, here & now	Strategic, future outcomes
Equation parameters	Pp+=1, Ppf=1	Ps+=1,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

Mesial – Dorsolateral distinction

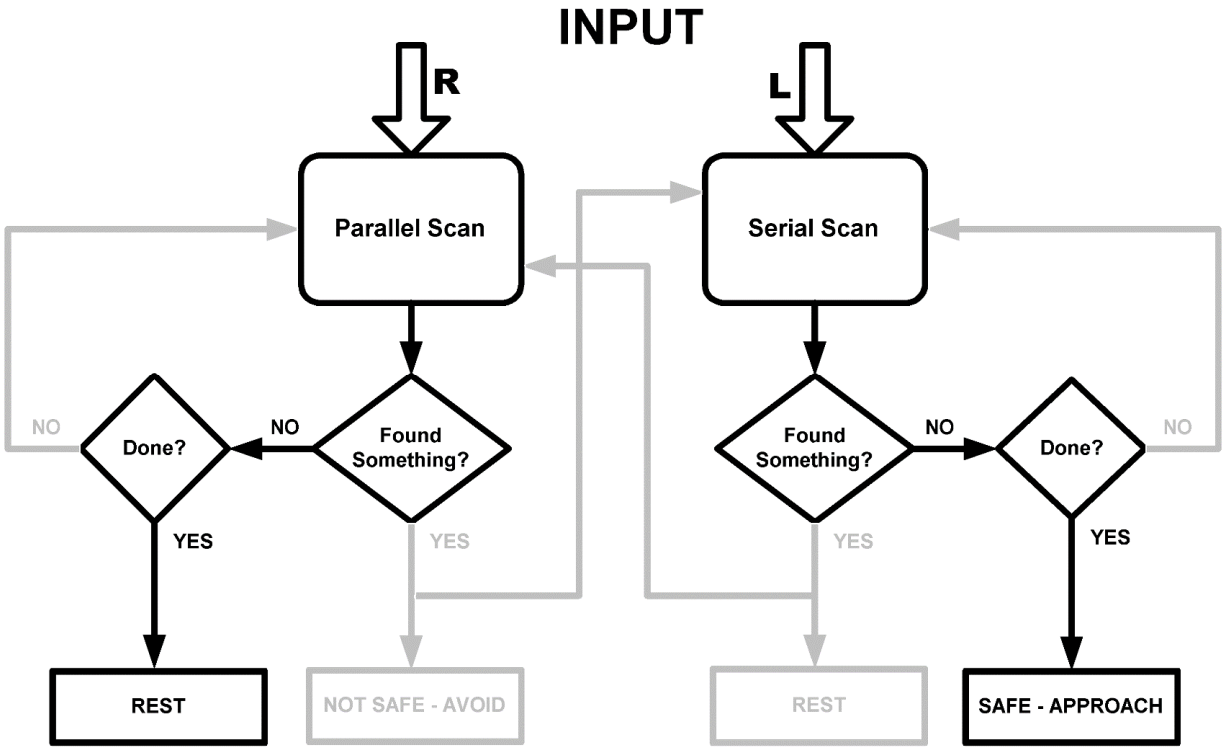
- Mesial – primary emotional sensation
  - Fundamental, initial sense –”nice” or “not nice”
- Dorsolateral – seconday emotional perception
  - Integrated with memory
  - Put into context
  - Can turn interpretation “around”

Emotional Decision Making Model

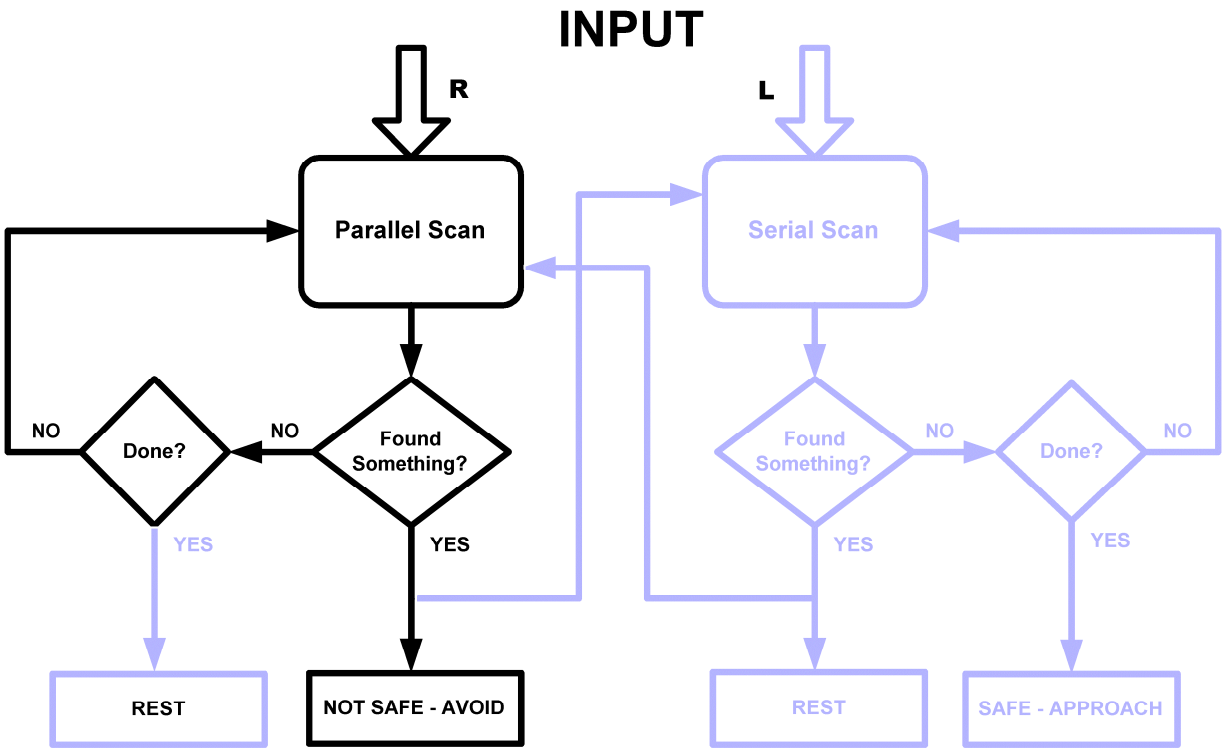
(why we downtrain alpha on the left dorsolateral frontal lobe)



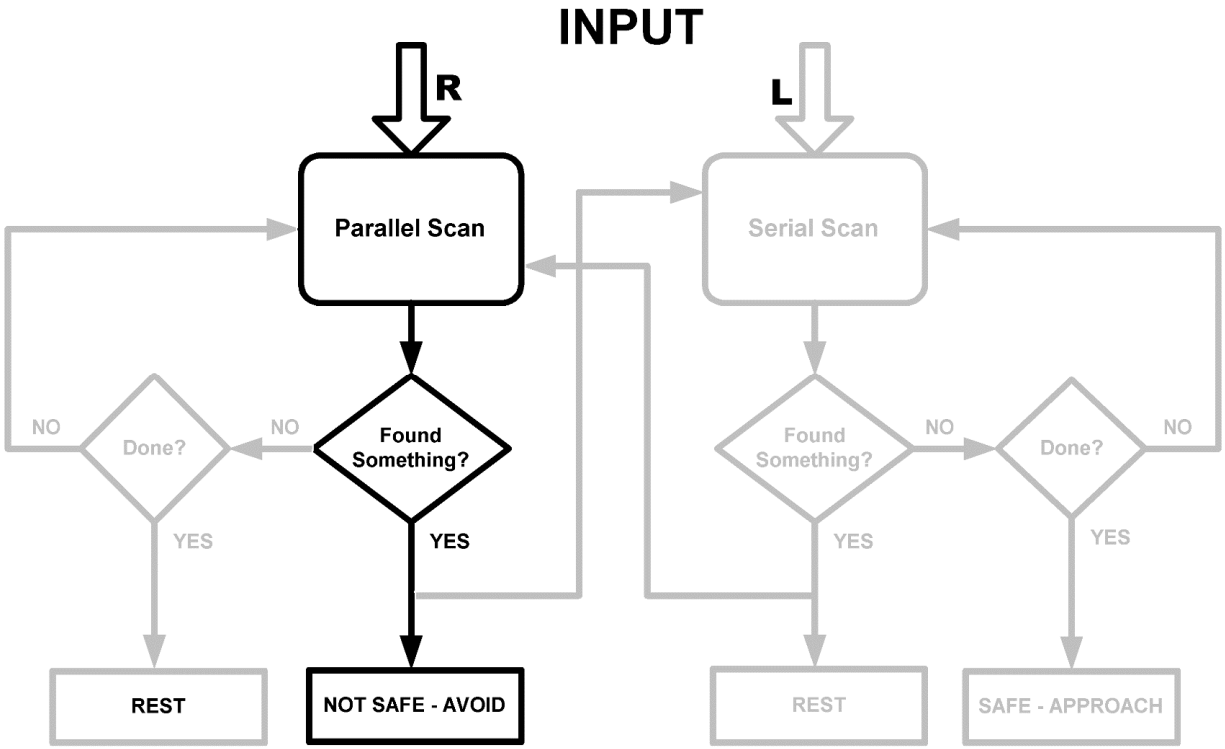
Happiness as a process



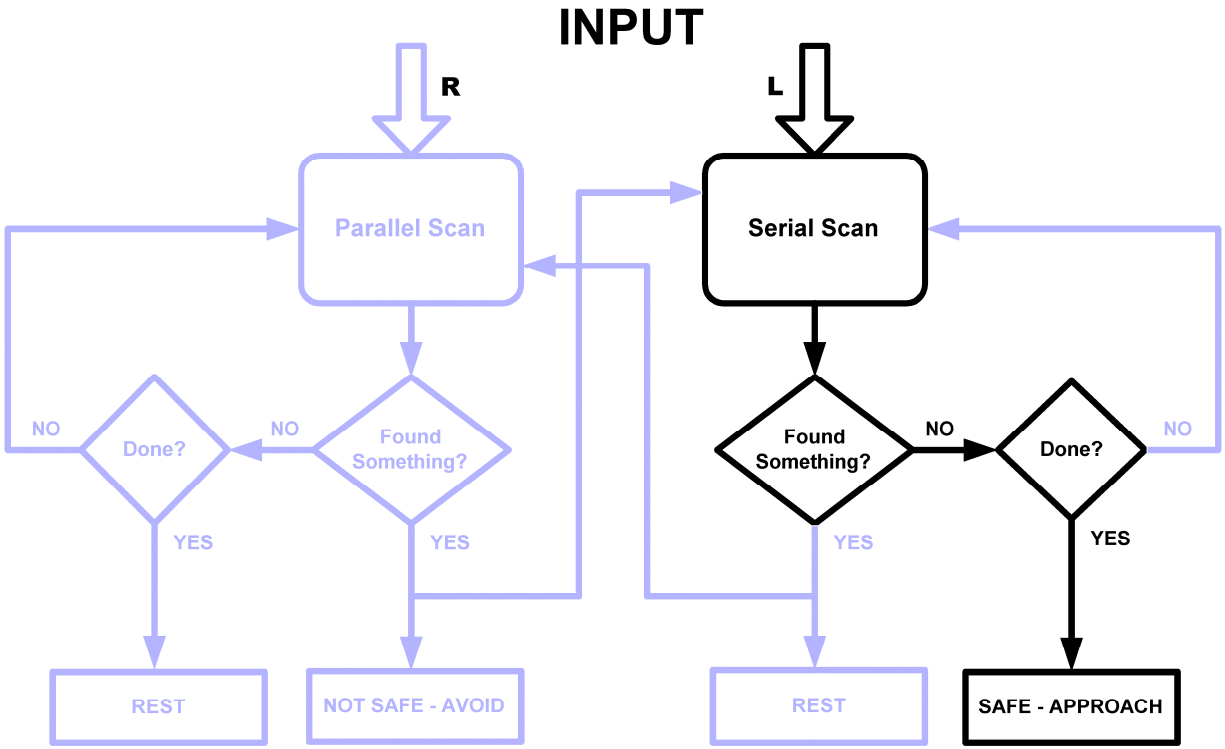
Depressed



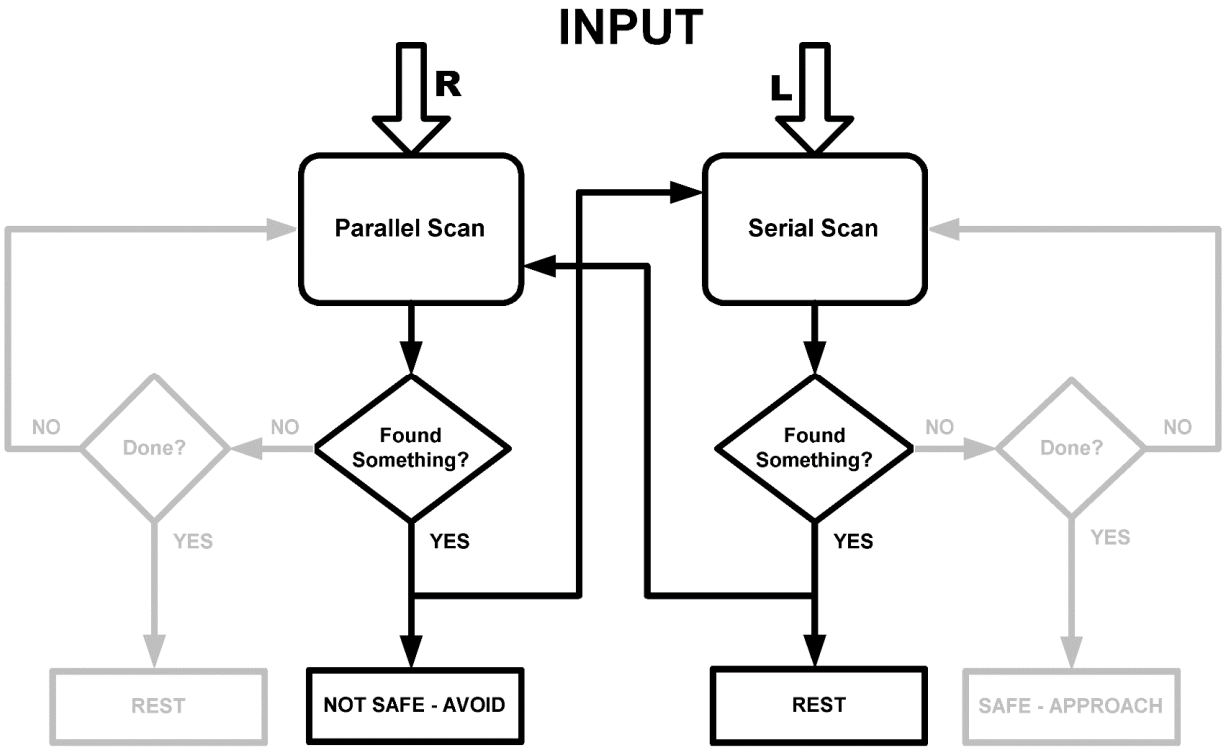
Paranoid



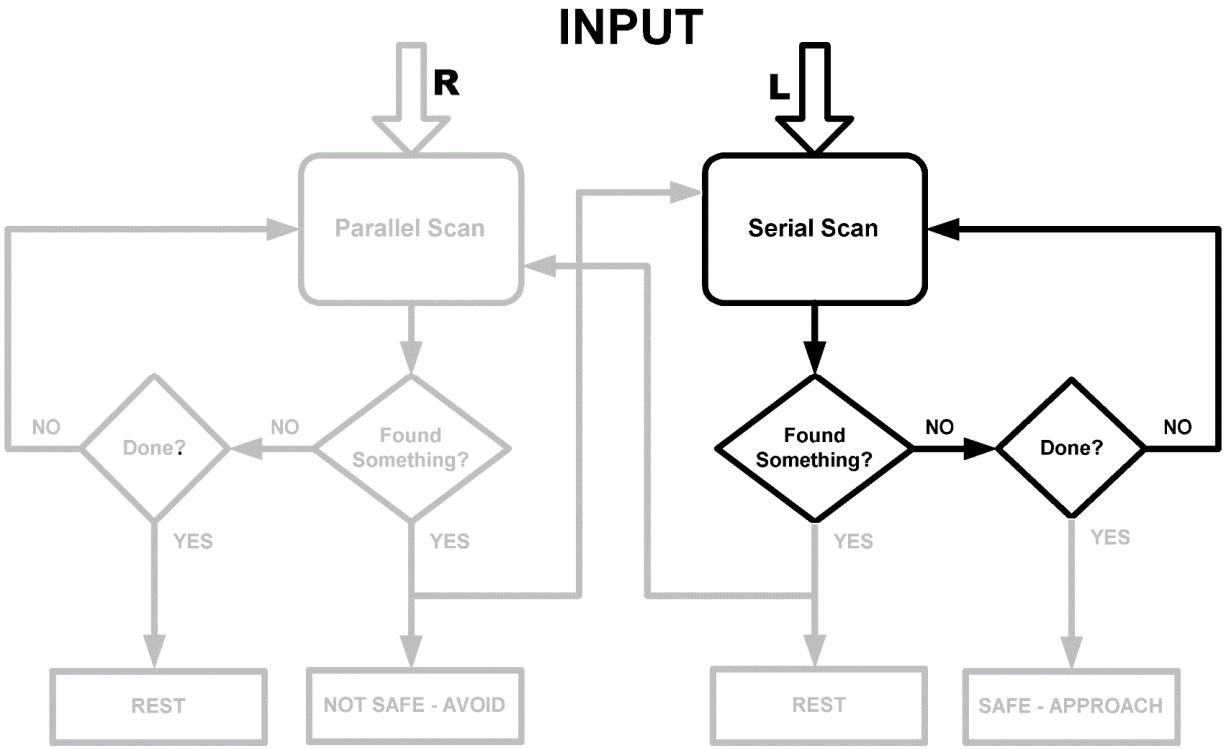
Risktaker



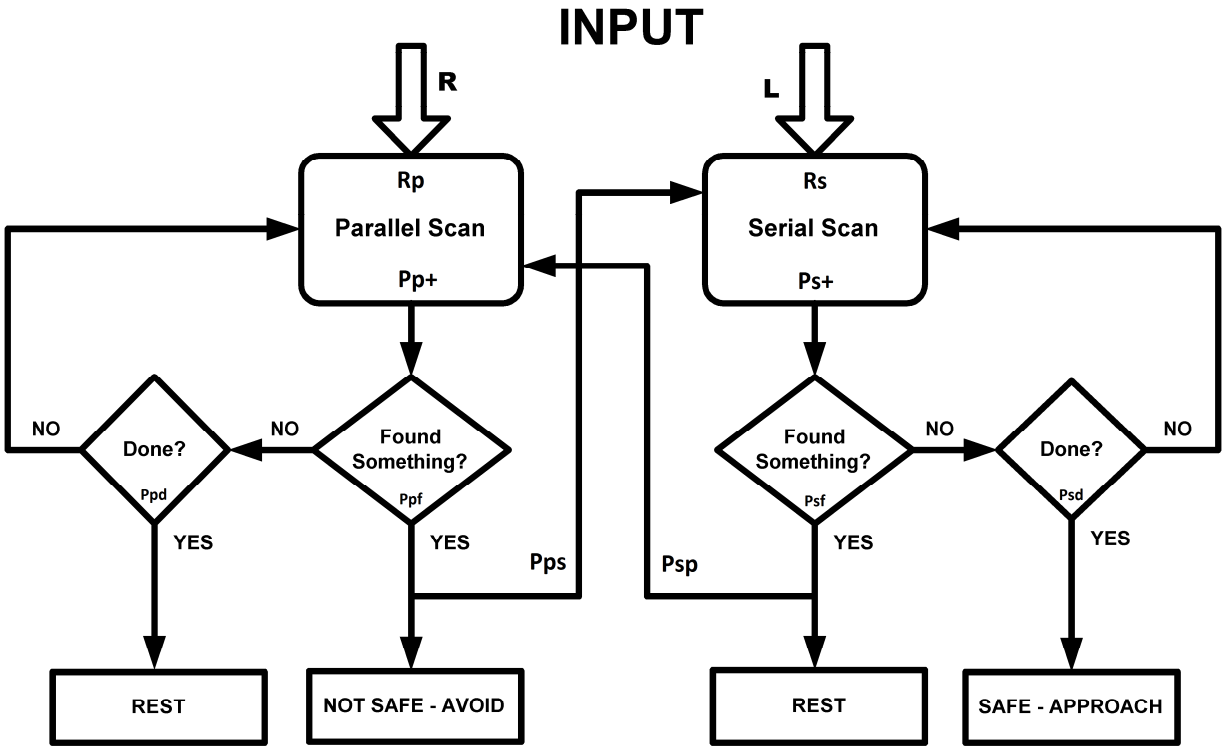
Chronic Anxiety



General Anxiety



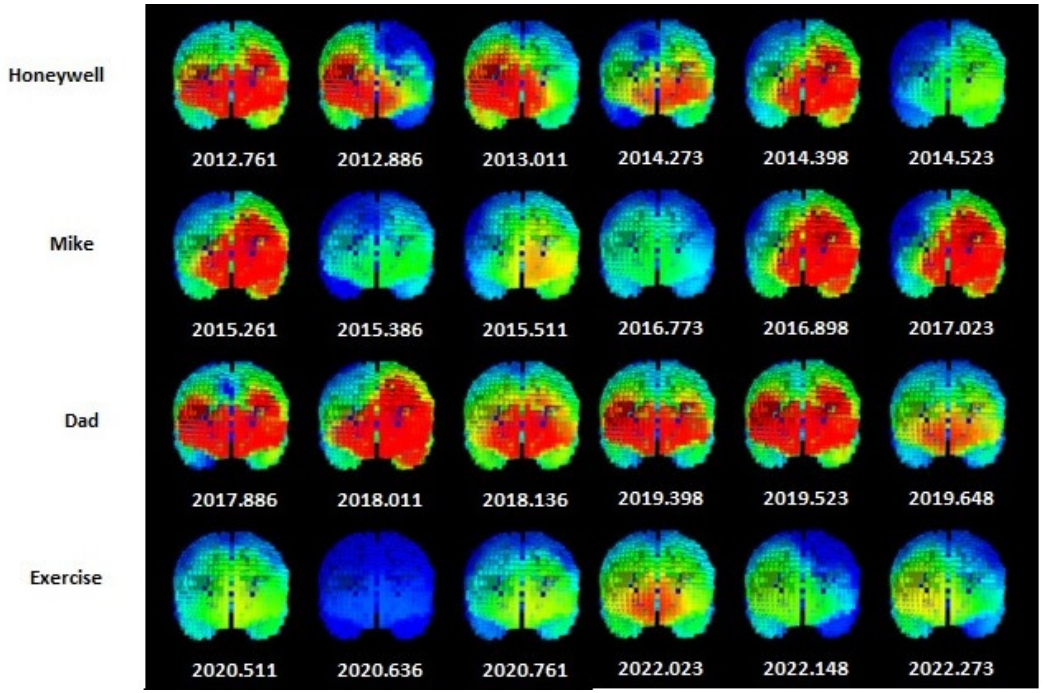
Quantitative Model



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	+	+	+							

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

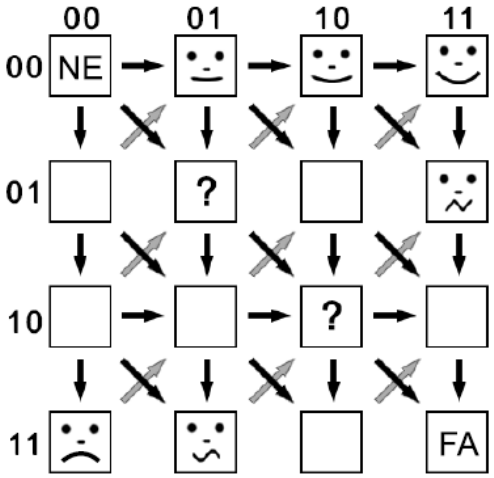
1011 -

1100 - avoid full

1101 - negative inspite of + feel

1110 -

1111 - full alert

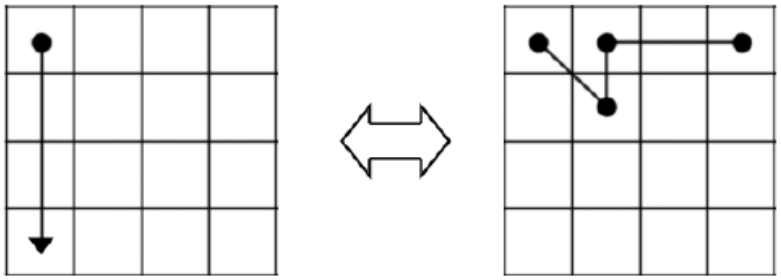


Crystals in time

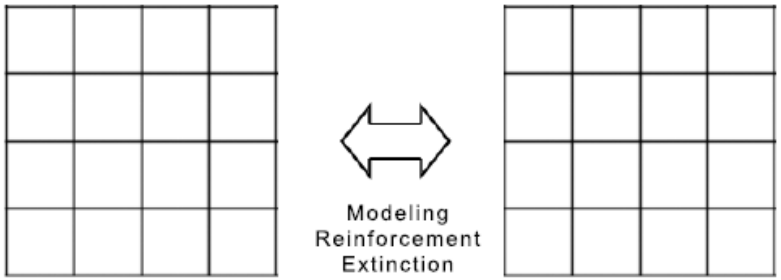
easier to remember bad experiences

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

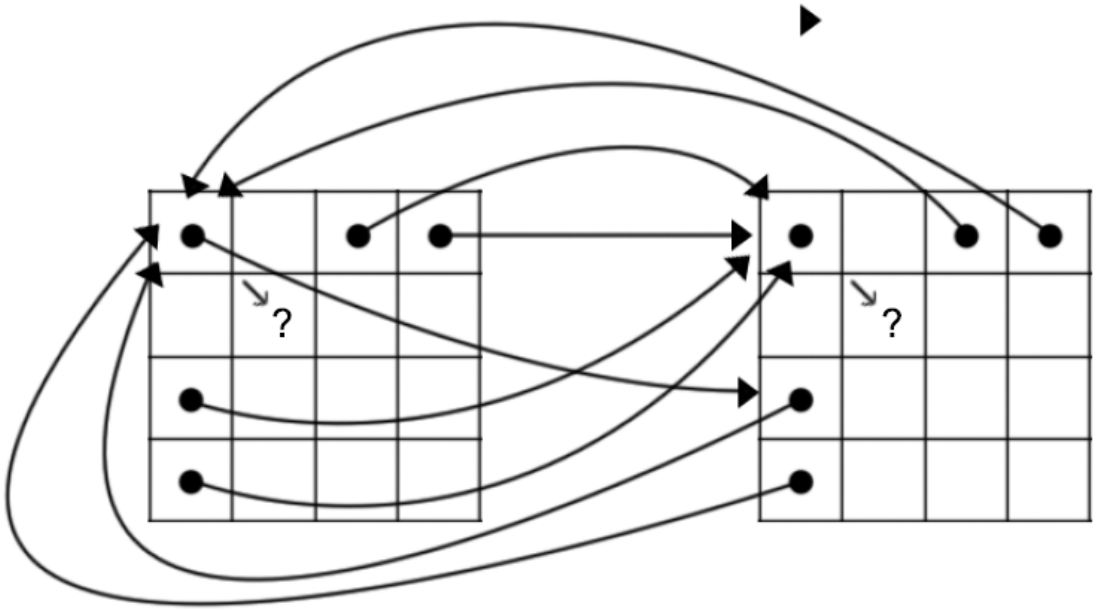
Patterns & Interactions



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+ 8- 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+ 8- SECONDARY+ + "Like" + "Mixed Judgement" FOLLOW HEART 1011
11	FULL + "Don't Like" + "Not Good" AVOID 1100	PRIMARY+ 8- SECONDARY+ + "Not Like" + "Not Good" FOLLOW HEAD 1101	PRIMARY+ 8- 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