NeuroRegulation

Frontal Gamma Asymmetry as a Forensic Tool for Emotional Valence in a Murder Case Study

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Abstract

In criminal cases, forensic evaluations often hinge on determining a defendant's competence and intent. Assessing underlying emotional states presents unique challenges, as self-reports may be unreliable or incomplete. In this exploratory single-case study, we illustrate how psychological assessments can be combined with quantitative EEG (qEEG) and source localization techniques to examine neural markers of emotional processing in the context of a murder trial. Emotional valence toward key individuals and events was derived from a proprietary frontal gamma asymmetry protocol. Although this innovative metric offers unique insights, it has received limited independent replication and should therefore be interpreted cautiously and in conjunction with established measures such as frontal alpha asymmetry. Key procedural covariates, including the defendant's medication (sertraline), were documented because serotonergic agents can modulate baseline asymmetry patterns. Findings indicated general alignment between neural patterns and reported affect, but we emphasize that these observations reflect preliminary insights from a single individual and require validation in larger samples before supporting broader forensic applications.

Keywords: Frontal gamma asymmetry; quantitative EEG (qEEG); emotional valence; forensic neuroscience; mens rea assessment; Brodmann area 9 (BA9)

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Introduction

Mental health professionals are frequently called upon in murder cases to assist courts in determining both a defendant's competence to stand trial and their mental state at the time of the offense. Central to such evaluations is the concept of mens rea, or criminal intent, which is often decisive in distinguishing between degrees of culpability. Legal doctrine typically considers two elements of crime: the *actus reus* (the physical act) and the *mens rea* (the mental state). Modern interpretations of mens rea in homicide require juries not only to examine the subjective state of mind of the accused but also to contextualize this within the broader circumstances surrounding the crime (Nourse, 2002). Forensic psychologists therefore play a critical role in clarifying the extent to which psychological, neurological, or environmental factors may have shaped a defendant's intentions.

This case study explores these issues in the context of a 32-year-old male defendant charged with the murder of his uncle. The case illustrates the tension between claims of self-defense, the presence of longstanding family conflict, and questions regarding the defendant's emotional regulation and psychiatric history (Cantor, 2016). By situating the legal question of mens rea within a neuropsychological framework, the analysis demonstrates how complex family dynamics, mental health vulnerabilities, and situational stressors intersect in ways that complicate legal determinations of intent.

The defendant's background included exposure to chronic familial discord, parental mental health difficulties, and prior traumatic experiences. Research in trauma psychology has established that cumulative stressors and unresolved interpersonal conflicts can exacerbate mood dysregulation and increase vulnerability to reactive aggression (Ford & Courtois, 2021; Teicher & Samson, 2016). Reports of depressive symptoms, self-injurious behavior, and paranoid ideation further suggest a psychological profile consistent with difficulties in emotional regulation and resilience. These elements not only provide context for the defendant's actions but also align with forensic psychiatry literature that emphasizes the role of psychiatric comorbidity in shaping violent outcomes (Chow et al., 2025).

Within neuroscience, frontal alpha asymmetry has long served as a proxy for emotional valence, with greater relative left frontal activity associated with approach related to positive affect and right frontal activity linked to withdrawal or negative affect (Davidson, 1998). Gamma band asymmetry, by contrast, is a more recent and largely proprietary extension that aims to capture faster, preconscious aspects of valence processing. Because the scientific literature on gamma asymmetry is much smaller than that on alpha, it is important to contextualize our approach as an experimental adaptation of established theories rather than a replacement and to recognize that the evidentiary base for forensic application is still emerging.

To frame the legal defense, it is important to consider the range of arguments typically available in murder cases, from mistaken identity to insanity pleas. Table 1 outlines common defenses and highlights how each applies—or fails to apply—in this case. For example, while self-defense could be argued given the victim's threats and perceived reach for a weapon, its validity was undermined by the defendant's continued use of lethal force after the victim was incapacitated. Conversely, the defense team emphasized the possibility of a trauma-related psychiatric condition, positioning the defendant's actions as stemming from an acute emotional cascade rather than premeditation.

Table 1 thus serves not merely as a legal overview but as an interpretive tool to clarify why certain defenses were dismissed and why others, particularly those invoking psychiatric explanations such as temporary insanity, became central to the case strategy. This framing highlights the challenges courts face in relying on subjective accounts of emotional states, underscoring the need for more objective neuropsychological measures to evaluate intent and motive.

Table 1

Common Defenses in Murder Cases and Application to the Present Case

Type of Defense	General Explanation	Application to This Case
Mistaken Identity	Defendants may argue that the prosecution has charged the wrong person with the killing.	Not applicable: multiple eyewitnesses observed the defendant commit the act.
Justified Homicide	Some killings are considered legally justified, such as those in lawful defense.	Partially relevant: the victim initiated threats; however, subsequent excessive force undermined this argument.
Self-Defense	Requires evidence that the killing resulted from a reasonable and proportional response to an imminent threat of death or serious bodily harm.	Weakly applicable: although the victim threatened and appeared to reach for a weapon, the defendant continued firing after the victim was incapacitated.
Defense of Others	Use of force may be justified to protect others from imminent harm, provided it is reasonable and proportional.	Considered but not substantiated: the threat was directed at the defendant rather than others present.

Table 1
Common Defenses in Murder Cases and Application to the Present Case

Type of Defense	General Explanation	Application to This Case
Exercise of Duty	Killings by law enforcement or public officers in the line of duty may be justified.	Not applicable: defendant was a private citizen.
Accident or Misfortune	Unintentional killings occurring during lawful activity may reduce liability to manslaughter.	Not applicable: multiple deliberate shots were fired.
Insanity Defense	Based on the inability to appreciate the nature of the act or to understand its wrongfulness due to mental illness or cognitive impairment.	Most relevant: defense strategy emphasized trauma-related psychiatric conditions and possible 'temporary insanity' stemming from prior family conflict and emotional dysregulation.

Methods

Psychological Evaluation History and Test Battery (Current Functional Status)

The defendant was reportedly born at term via uncomplicated vaginal delivery, and he described his early developmental history as unremarkable. There is no documented evidence of prenatal drug or alcohol exposure in the available records, although prenatal history was based solely on his self-report and is therefore limited. His medical history included intermittent headaches, dizziness, visual blurring, fatigue, chest pain, palpitations, allergies (penicillin), and lower-back pain, with no known neurological disorders. He has experienced lifelong depression, anxiety with panic episodes, attentional problems, and periods of impulsivity, and has a history of self-injurious cutting following his father's death. He had been treated with sertraline (Zoloft) 200 mg daily for approximately 2 years, which he reported taking consistently, including at the time of the alleged offense. He also reported regular alcohol use (approximately two shots nightly for sleep). Prior medical care included allergy immunotherapy during childhood and brief treatment for acid reflux. Family history is notable for significant psychiatric disorders (depression, anxiety, suicidality), learning problems, deafness in both parents, and substance abuse in multiple relatives, indicating a substantial hereditary vulnerability to mood and behavioral dysregulation.

A psychological battery was administered to assess cognitive, behavioral, personality, and emotional functioning using age-normed instruments with established reliability. Tests included:

- 16 Personality Factor–5 (16PF)
- Adult Self-Report, 18–59 (ASR/18–59)
- Adult Manifest Anxiety Scale–Adult (AMAS-A)
- Behavior Rating Inventory of Executive Function–Adult (BRIEF-A, self and informant)
- Green's Word Memory Test (WMT)
- Integrated Visual and Auditory Continuous Performance Test (IVA/CPT)
- Miller Forensic Assessment of Symptoms Test (M-FAST)
- Minnesota Multiphasic Personality Inventory–2 (MMPI-2)
- Sensory Profile (Adolescent/Adult)
- Trauma Symptom Inventory (TSI)
- Wechsler Adult Intelligence Scale–IV (WAIS-IV)
- Wide Range Achievement Test–4 (WRAT-4; selected subtests)
- Neurometric qEEG

Administration/Scoring. All instruments were administered and scored per publisher manuals within a single evaluation period preceding EEG acquisition. Standard validity checks (e.g., MMPI-2 validity scales, WMT performance indicators) were used to determine interpretability. Instruments were selected for their routine forensic relevance (general intellectual ability, effort/response validity, executive function, attention, personality/psychopathology, trauma, anxiety/depression).

Rationale for Instrument Selection. Instruments were selected to capture distinct constructs relevant to forensic competence: the WAIS-IV and WRAT-4 assessed general intellectual ability and academic skills; the WMT and M-FAST evaluated effort and response validity; the BRIEF-A and IVA/CPT measured executive attention and inhibitory control; the 16PF, MMPI-2, AMAS-A, and TSI characterized personality, psychopathology, anxiety, and trauma exposure; and the Sensory Profile and ASR provided contextual information on sensory processing and adaptive behavior. Together, these measures addressed competence to stand trial, potential mitigating mental disorders, and possible malingering, aligning with forensic best practices.

Behavioral Analysis

Prior to the EEG data collection, a 10-min behavioral assessment tool provided by Target Training International (TTI) was administered (Gehrig & Bonnstetter, 2021). The tool subdivides a person's behaviors based on the strength of four constructs: (D) dominance, (I) influencing, (S) steadiness, and (C) compliance. This tool was administered to document the defendant's baseline behavioral style to aid stimulus selection and finally to align subsequent EEG measures with self-reported traits.

Neurometric qEEG Examination

Hardware/Montage. EEG was acquired using a Cadwell Easy II amplifier with a 19-channel 10–20 montage (Fp1, Fp2, F7, F3, Fz, F4, F8, T3, C3, Cz, C4, T4, T5, P3, Pz, P4, T6, O1, O2). Data were collected eyes open with a 1–70 Hz band-pass and a 60 Hz notch filter. Frequency metrics were computed for delta (1–4 Hz), theta (4–8 Hz), alpha (8–12 Hz), beta (12–25 Hz), beta-2 (25–35 Hz) and gamma (38–42 Hz). Medication status at the time of testing was recorded (sertraline/Zoloft, 20 mg daily) as a procedural covariate.

Source Localization. Three-dimensional current density maps were generated with sLORETA. By activation, we refer to an observed increase in the measured sLORETA current source density (CSD) level, when compared with the baseline level at rest, which is measured from the EEG immediately preceding each stimulus. Given that the subject was on setraline it is important to know that selective serotonin reuptake inhibitors such as sertraline (Zoloft) can influence electrophysiological measures of brain activity obtained through quantitative EEG and source-localization techniques such as sLORETA. These medications increase extracellular serotonin by inhibiting the serotonin transporter, thereby modulating cortical excitability and altering the balance between excitatory pyramidal neurons and inhibitory interneurons within cortical networks (Knott et al., 1996; Leuchter et al., 2012). Gamma-band activity is particularly sensitive to these effects because gamma oscillations reflect synchronized activity of local cortical circuits and GABAergic interneurons. Pharmaco-EEG studies have shown that selective serotonin reuptake inhibitors (SSRI) treatment may produce modest increases in frontal gamma activity and improved synchronization of cortical oscillations in individuals with mood or anxiety disorders. These changes are thought to reflect greater stability of cortical network functioning and improved integration within prefrontal regulatory systems (Arns et al., 2015; Knott et al., 1996). Source-localization studies using standardized low-resolution electromagnetic tomography have similarly demonstrated treatment-related increases in activity within the dorsolateral prefrontal cortex, particularly in Brodmann areas 9 and 46, following successful antidepressant treatment (Leuchter et al., 2012; Pascual-Marqui, 2002). Such findings are generally interpreted as reflecting enhanced engagement of prefrontal executive networks that exert top-down regulatory control over limbic emotional systems. In addition to regional activation changes, antidepressant treatment has been associated with greater stability of EEG microstates and more coherent transitions among transient functional brain states. These effects suggest improved coordination across distributed neural networks and more stable large-scale cortical dynamics (Arns et al., 2015; Lehmann et al., 1998). Overall, the electrophysiological literature indicates that treatment with sertraline may be associated with modest increases in prefrontal cortical activity, stabilization of gamma-band oscillations, and more organized temporal dynamics of cortical network activity. However, there are no known effects to induce influence on frontal gamma asymmetry in either direction with the use of SSRI agents.

Paradigm to Assess Emotional Valence via Frontal Gamma Asymmetry

Gamma activity was measured by taking the average of all voxels within each region of interest (ROI). The sLORETA model was used for all computations, using the T matrix published by Pasqual-Marqui (2002). The ROI for Brodmann area 9 (BA9) contained 225 voxels per side, for which the CSD was calculated for each voxel, and the average CSD used as the measured value. Gamma activity was recorded by processing the EEG at 256 samples/s with a digital filter (quadrature type, order 3) with corner frequencies set at 35 and 45 Hz. The quadrature filter provided instantaneous estimates of gamma amplitude through complex demodulation, for the moment-to-moment changes in gamma amplitude. These were projected to sLORETA space using a local T matrix, at the rate of 6239 voxels (x, y, and z) times 256 samples, for a processing rate 5 million sLORETA voxel calculations per second. Amplitude samples of the sLORETA voxel amplitudes were taken at intervals of 125 ms, providing 8 estimates per second of the entire sLORETA projection, reflecting the momentary changes in brain microstates. The rate of 8 images per second was limited primarily by the ability to generate and save images at that rate on a high-speed PC. While a faster rate of reconstruction may be of benefit, it was confirmed visually that the successive images using sLORETA demonstrated a smooth set of transitions, with no evidence of missing states. It was also confirmed by taking data at 12 images per second, that no new information was evident when using a faster rate.

Trigger Derivation

Researchers reviewed case materials (interviews, testimony) to derive 33 single words or short phrases representing key persons/events**.** The defendant completed a paper-and-pencil Likert rating for each item to anchor stimulus categories.

Stimulus Presentation and EEG Recording Protocol

Detailing all protocols used for the following frontal lobe gamma asymmetry process is beyond the scope of this article. The interested reader may consult (Bonnstetter, Bonnstetter, et al., 2015; Bonnstetter et al., 2016; Bonnstetter & Collura, 2020; Bonnstetter et al., 2012; Bonnstetter et al., 2022; Bonnstetter et al., 2018; Bonnstetter, Hebets, et al., 2015; Collura & Bonnstetter, 2020; Collura et al., 2016; Collura et al., 2014a; Collura et al., 2014b). These references will highlight the original application of gamma for ipsative validation using electroencephalography (GIVE) process to access asymmetric gamma wave bursts in the prefrontal cortex to validate the underlying preconscious decisions behind self-report responses at the very moment of decision-making.

The following analysis used the same process to expose the underlying mental state at the moment of decisions, thus revealing the thoughts and emotional load behind responses. This process reveals the likely evoked emotionally laden brain activity and documents both the intensity of human emotional responses and the directionality of the response.

Asymmetries in the frontal lobes with increased gamma in the right hemisphere have been identified with events or individuals experiencing an aversive reaction, while increased gamma activity in the left frontal region has been correlated to positive regard. Symmetric activity is typically noted in the frontal lobes with events that have been correlated to a neutral emotional reaction (Bonnstetter, Hebets, et al., 2015).

Documented Gamma Asymmetry Protocols

At the time of this case study, several international and national professional presentations had been made describing this process of identifying emotional valence, but only one peer-reviewed article had been published on the protocols (Bonnstetter et al., 2012). With this in mind, great care was given to document the process used in an effort to provide further insight regarding the defendant’s emotional reactivity to key individuals and events related to the felony murder case. The first step for the researchers was to review hundreds of pages of testimony to derive a list of events and key people tied to the case so as to capture and rate the extent of his likely positive or negative feelings for each possible trigger. Prior to collecting EEG imaging and qEEG data, the client was asked to fill out a survey composed of 33 questions that would ultimately be used as stimuli for the EEG imaging.

Stimuli were programmed on a presentation workstation and displayed centrally on a monitor while EEG was recorded.

- Presentation software: E-Prime (timing control).
- On-screen duration: 1.5 s per item.
- Inter-stimulus interval: Randomized black screen 2–3 s**.**
- Runs: Two exposures to all 33 items, with a 5-min interval between runs (the second run served as a within-session replication).
- EEG acquisition for gamma asymmetry used BrainMaster BrainAvatar™ hardware and software in conjunction with the Cadwell system; raw EEG/EDF files were exported for postprocessing.

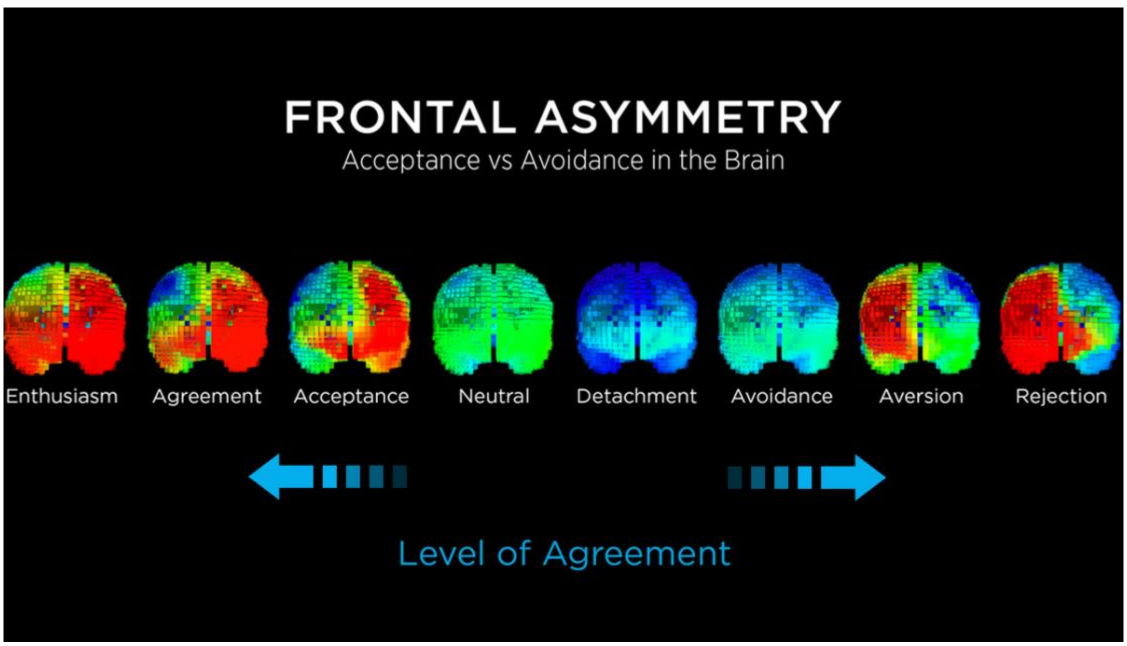
Processing and Analysis (Replication Details)

- Preprocessing: band-pass 0.5–40 Hz for artifact-sensitive analyses; ocular and muscle artifacts addressed using routine artifact rejection procedures (with independent component or equivalent artifact inspection and removal as needed).

- Spectral features: power estimates were calculated for standard bands and gamma (≈38–42 Hz) for asymmetry indices.
- Asymmetry metric: frontal gamma from F3/F4 (natural log transform), Asymmetry = ln(right) – ln(left) computed at the trial level and summarized by stimulus condition.
- Source imaging: sLORETA current density maps generated from stimulus-locked epochs.
- Reference/thresholding**:** age-normed databases; deviations considered notable at |Z| ≥ 2.0 (documentation retained in the case archive).
- Replication check: first versus second run compared for direction consistency (see Findings).

Figure 1 presents an example of frontal lobe gamma asymmetry with positive, neutral, and negative responses. The orientation of the brain is facing forward such that the right hemisphere is on the left side of the image. The red indicates an increase in gamma activity, the blue indicates a decrease in activity, and the green indicates little or no activation. In addition to color depicting a range of response intensity, the gamma burst location is also key to interpretation. A left frontal lobe flare is an indication of acceptance or a positive response and a right-side flare demonstrates avoidance or a negative response to a stimulus.

Figure 1. *Frontal Asymmetry.*



Findings

Psychological Battery

Behavioral observations during testing indicated adequate attention**,** consistent effort, and cooperative engagement**,** supporting validity of the results. Performance suggested average intellectual functioning (WAIS-IV) with relative weakness in visual processing**.** Self-report measures reflected elevated anxiety and intermittent depressive symptoms relative to age-expected norms. Screening indicated borderline attentional difficulties**;** informant ratings on parallel executive-function/attention items were not elevated**,** suggesting limited collateral awareness of the defendant's internal distress or functional complaints. The defendant self-reported executive-function challenges (planning, organization, initiation, flexibility) that were not corroborated by informant ratings. On a computerized CPT, overall indices were age-average**,** with mild impulsivity tendencies to auditory targets. Personality profiles were consistent with introversion**,** limited social trust**,** and heightened anxiety**,** with episodic depressed mood. The totality of data supported that the defendant was competent to stand trial.

Behavioral Analysis

Figure 2 depicts the defendant's adapted and natural behavioral styles. The "natural" style index represents a sense of self, and the "adapted" style index describes how a person might be adapting to their environment.

The primary "S" behavioral style suggests that the defendant is likely very loyal, enjoys stability and consistency and typically is very slow to anger. Such individuals value relationships, typically with a smaller group of people with whom they form strong bonds. Because of this tie to close relationships, family tends to be extremely important to them. The dominant "S" style, coupled with the high "C" style suggests a person follows rules and regulations. While the high "S" style tends to be refrained, when pushed beyond some critical emotional point, they tend to overreact.

It is also noteworthy to point out that Graph I and Graph II are basically identical, which indicates that these descriptive characteristics are consistent likely to a high likelihood of stability over time and therefore most likely applicable to the time of the murder.

Figure 3 is a similar chart but with word descriptors highlighted with color bands to depict his "natural style." A quick review of the descriptive words in each of the four columns lay the groundwork for a better understanding of the defendant's natural behavioral style.

Limitations of the Behavioral Style Assessment. The DISC-derived behavioral style report is a commercially available tool designed for workplace coaching rather than clinical diagnosis. Its adaptation here provided descriptive information about natural versus adapted interpersonal tendencies but has not been validated for forensic decision-making or for assessing emotional reactivity under high-stress conditions. Consequently, interpretations drawn from this measure should be seen as provisional and supplementary to the more rigorous neuropsychological and neurophysiological data.

Figure 2. *Defendant's Adapted and Natural Behavioral Styles.*

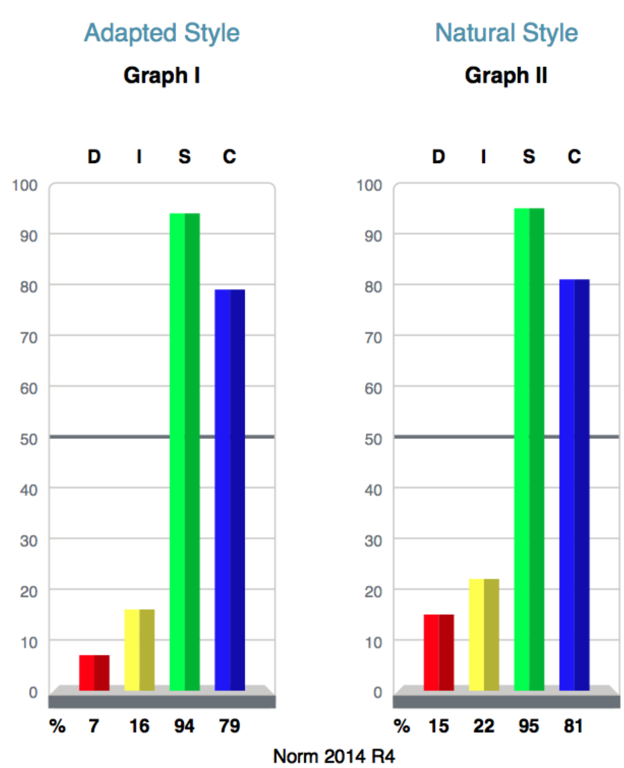
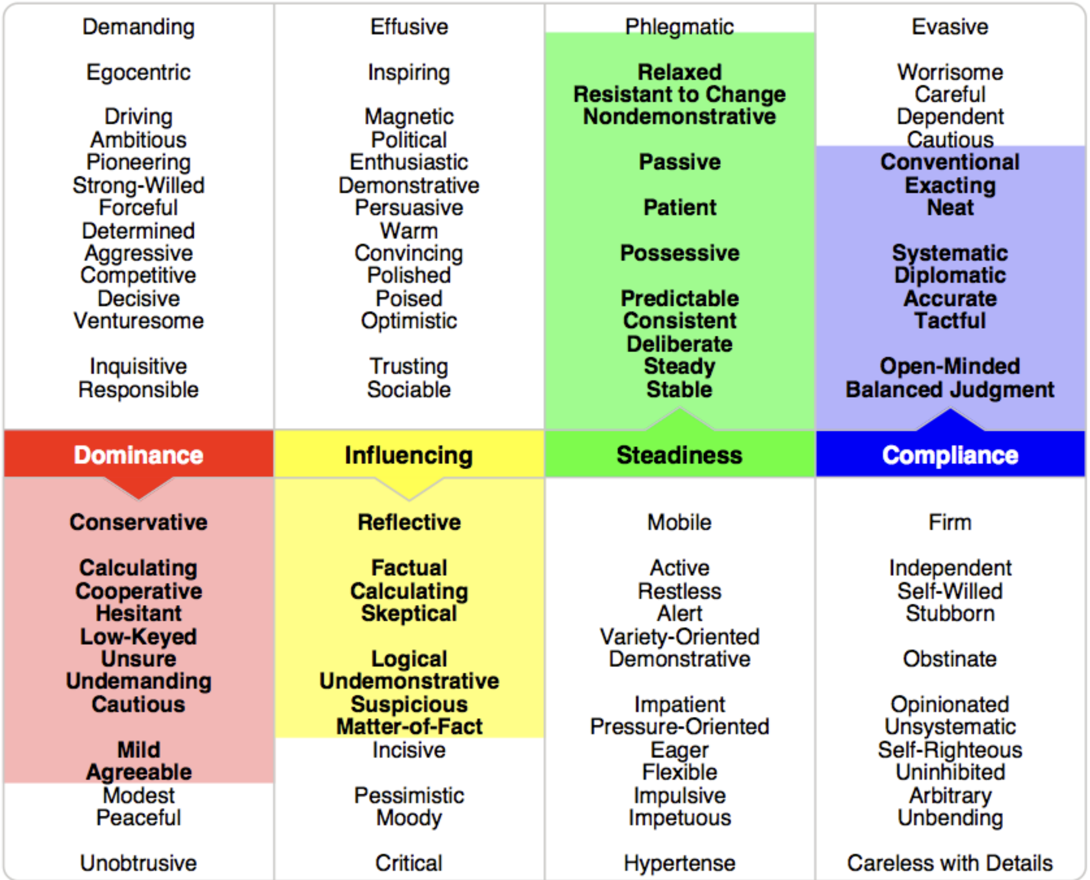


Figure 3. *Word Descriptor Chart.*



QEEG / sLORETA Findings

Eyes-open qEEG with sLORETA revealed a marked alpha current-density increase in BA9 (dorsolateral prefrontal cortex), approximately ~4 *SD* above age-normed means in resting state. Interpretively, this focal alpha elevation was treated as nontrivial given BA9's role in cognitive–affective integration and regulatory control. Medication status (sertraline) at the time of testing was noted as a possible physiological confound; while normative comparisons were conducted against population data, no sertraline-matched subgroup analyses were available. Selective serotonin reuptake inhibitors have been reported to increase frontal alpha power in resting EEG, necessitating caution in attributing the observed elevation solely to psychopathology.

Gamma Asymmetry (Emotional Valence)

The gamma asymmetry approach employed here derives from the guided imagery valence evaluation (GIVE) process described by Bonnstetter et al. (2018) and further developed by Collura and Bonnstetter (2020). It assumes that lateralized gamma band activity between 38–42 Hz indexes preconscious affective reactions to stimuli. This model posits that right-dominant gamma reflects aversive/avoidant valence, whereas left-dominant gamma reflects approach/positive valence, with symmetrical patterns indicating neutral responses. These assumptions extend traditional alpha asymmetry theories into higher-frequency bands; however, independent peer-reviewed replication is limited, and alternative frameworks (e.g., beta asymmetry or theta connectivity) exist for indexing emotional processing. Therefore, the findings reported here should be interpreted within a provisional conceptual model rather than as definitive evidence of latent emotion.

Frontal gamma asymmetry patterns were used to infer valence direction: right-frontal > left associated with aversive/avoidant**,** left-frontal > right with approach/positive**,** and symmetry with neutral responses. Across stimuli:

Directionality was stable across both runs; the second run showed reduced intensity consistent with habituation, but valence direction was unchanged, as shown in Figure 5.

Figure 4. *Eyes-Open Brain Functional Analyses Showing 3D sLORETA Findings Indicating a Maximum Increased Alpha Current Density in Brodmann Area 9.*

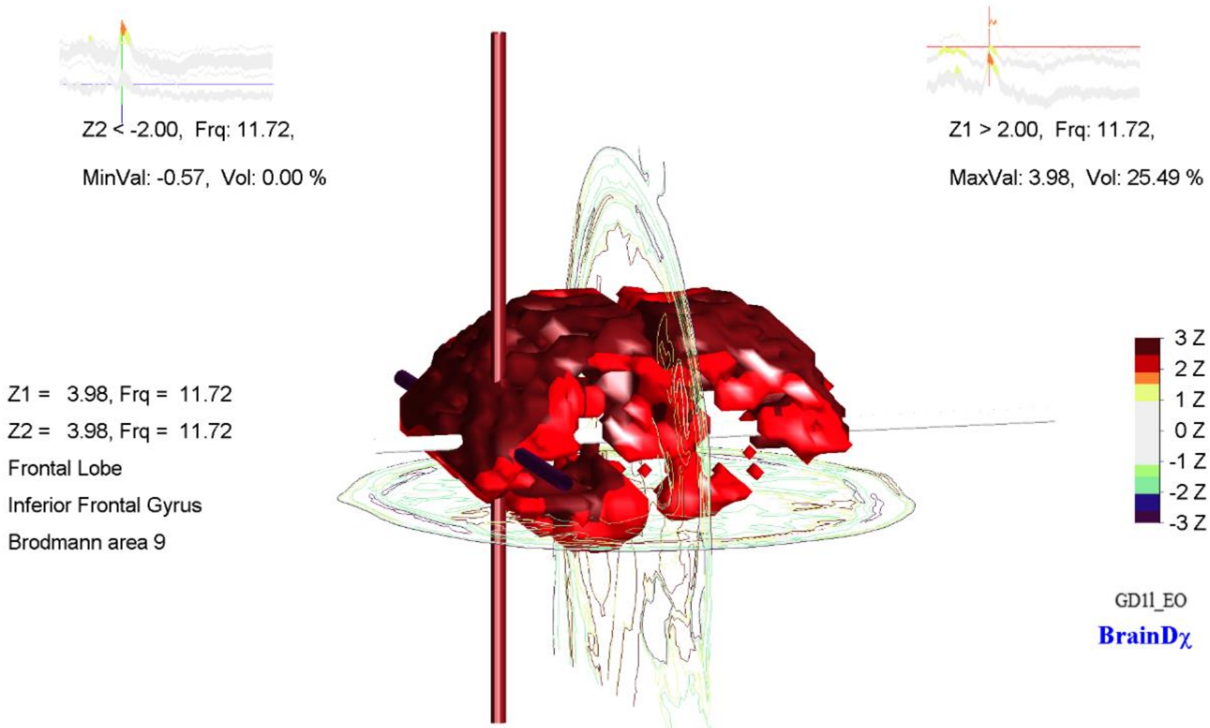
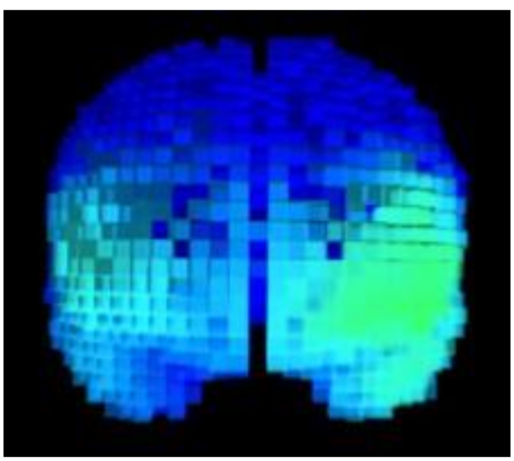


Figure 5. *First Run Baseline Image Second Run Baseline Image.*



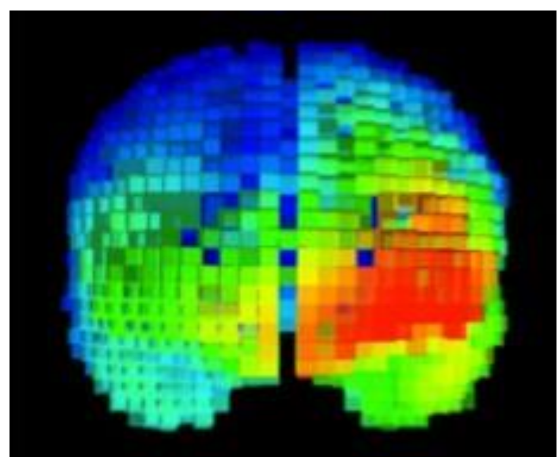


Figure 5 depicts this habituation, even in the client's baseline status; yet in both runs, the client exhibited a left-dominant asymmetry. The image of the frontal cortex is facing the observer, so the red is on the left side of the brain.

Baseline images in both runs showed left-dominant asymmetry. In the lab's broader experience set, less than 10% of more than 200 clients exhibit left-dominant baselines; when present, it has frequently been observed among individuals reporting meditation practice or elevated positive affect at recording. In the present case, sertraline (Zoloft) may also have contributed to baseline left dominance.

Paper-and-pencil ratings showed few extreme responses (only three items at the most extreme end), broadly mirroring the moderated EEG reactivity.

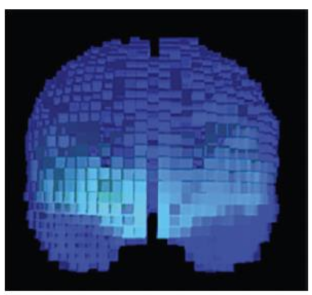
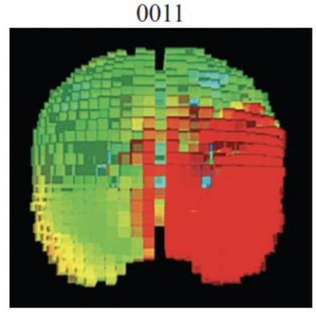
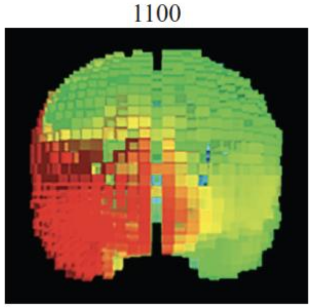
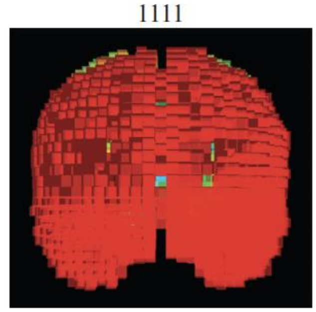
To quantify the magnitude of asymmetry responses, gamma asymmetry indices were calculated for each stimulus as the normalized difference between left and right frontal gamma power. Across stimuli, effect sizes (Cohen's *d*) relative to a normative sample of more than 200 adults averaged 0.9 for aversive triggers and 0.4 for positive triggers, indicating large and moderate departures, respectively. Paired comparisons between baseline and stimulus conditions showed statistically significant differences in asymmetry direction (Wilcoxon signed-rank tests, $p < .05$), although these analyses remain exploratory given the single-case design.

Updated Display Protocols (Post Hoc Visualization)

Since the gathering of the initial EDF file from the defendant in 2016, an additional gamma asymmetry emotional model has been developed that takes into account the presence of moment-by-moment decision-making processing, referred to as microstates (Bonnstetter & Collura, 2020; Bonnstetter et al., 2022; Collura & Bonnstetter, 2020), and is employed on that original data set to expand on our understanding of the defendant's responses.

Employing the protocols of gamma asymmetry described by Bonnstetter and colleagues (2018), Figure 6 depicts the four corners of the model as sLORETA (standardized low-resolution brain electromagnetic tomography) images and how the upper left-hand corner with no activation can move through a continuum down to avoidance, across to approach or diagonally to full activation.

Figure 6. *Simplified Emotional Decision Model.*

	Lp Ls 00	10	01	11
Rs Rp 00	Not Activated 0000 			Full Like + Good Approach 0011 
01				
10				
11	Full - Dislike + Bad Avoid 1100 			Full Activated +/_ 1111 

The top row labels represent left frontal lobe primary and left secondary brain gamma (38-42 Hz). The first column represents the right frontal lobe and again depicts the secondary and primary possible responses. Regarding the numbers: 0 = *no activation* and 1 = *activation*.

This simplified version of the model that provided an introduction to the 16-cell model by elaborating on the four extremes. The upper left corner shows low or no activation as represented by both right and left numeric zeros (0000). The upper right corner shows an initial primary emotion (Like) and a secondary judgment (Good) in the left hemisphere and no response in the right (0011). The lower left depicts an initial emotion of dislike and a judgment of bad as shown by the right hemisphere gamma response and the lack of left hemisphere reaction (1100). The lower right-hand corner depicts full activation (1111).

While the 4×4 decision model and microstate analysis provided an illustrative framework for parsing complex gamma patterns, it is important to note that microstate segmentation of gamma activity remains experimental in forensic contexts. Simpler metrics, such as average asymmetry indices across time windows, may offer comparable discriminative power with fewer assumptions. Future research should directly compare microstate-based and traditional asymmetry methods to determine whether the added complexity yields meaningful improvements in forensic prediction.

Frontal Gamma Asymmetry as a Forensic Tool

Table 2 displays the resulting s-LORETA image, the corresponding trigger word or phrase, the defendant's Likert score paper and pencil response and the final decision as defined by the 4x4 model in Figure 6. For brevity, only the most useful images are shown.

Figure 7. *Resulting 16-Cell Decision-Making Model.*

Rs Rp \ Lp Ls	00	10	01	11
00	NOT ACTIVATED 0000	PRIMARY + "Like" PLEASANT 0010	SECONDARY + "Good" SAFE 0001	FULL + "Like + Good" APPROACH 0011
01	PRIMARY - "Dislike" UNPLEASANT 0100	PRIMARY +/- "Suspend Feeling" 0110	PRIMARY- SECONDARY+ "Dislike" + "Good" (Dieting) 0101	PRIMARY+/- SECONDARY+ + "Mixed Feeling" + "Good" FOLLOW HEAD 0111
10	SECONDARY- "Not Good" UNSAFE 1000	PRIMARY+ SECONDARY- "Like" + "Not Good" (NAUGHTY) 1010	SECONDARY +/- "Suspend Judgment" 1001	PRIMARY+ SECONDARY+/- "Like" + "Mixed Judgment" FOLLOW HEART 1011
11	FULL "Dislike" + "Bad" AVOID 1100	PRIMARY+/- SECONDARY- "Mixed Feeling" + "Bad" FOLLOW HEAD 1110	PRIMARY- SECONDARY+/- "Dislike" + "Mixed Judgment" FOLLOW HEART 1101	FULL ACTIVATED +/- 1111

Note. Emotional decision model. Rs, right secondary; Rp, right primary; Lp, left primary; Ls, left secondary.

Table 2
Resulting sLORETA Images

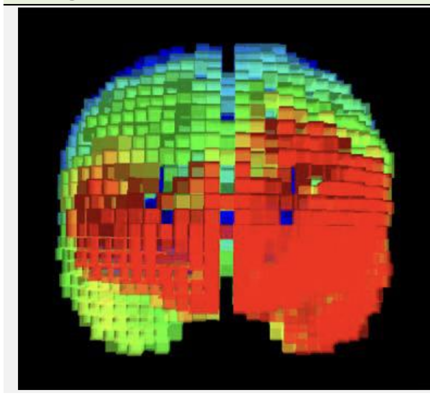
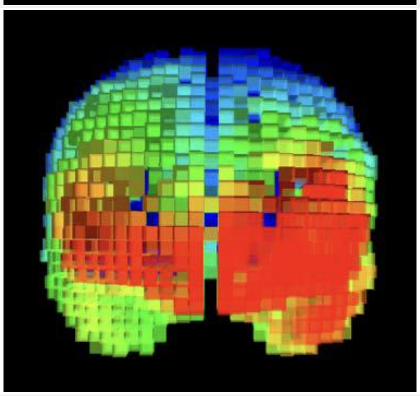
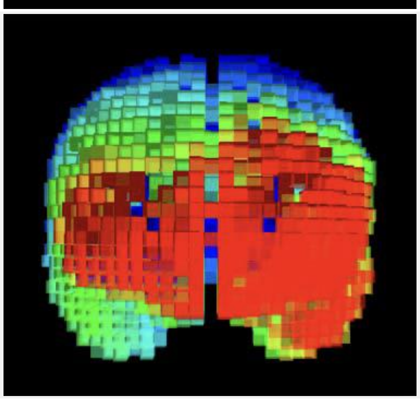
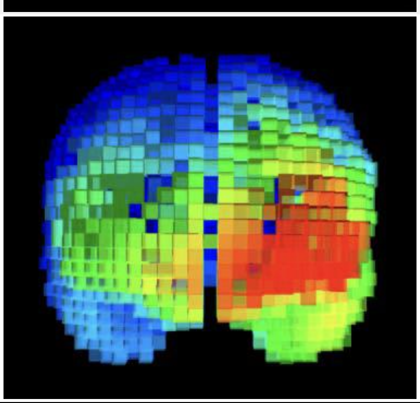
Image	Trigger	Likert Score	Resulting 4x4 Cell
	**Mother's name**	5	0111 Mixed Feeling + Good
	**Uncle is coming at me**	2	1110 Mixed feeling + Bad
	**Threats to mother**	2	0111 Mixed Feeling + Agree
	**Panic attacks**	1	0100 Dislike

Table 2
Resulting sLORETA Images

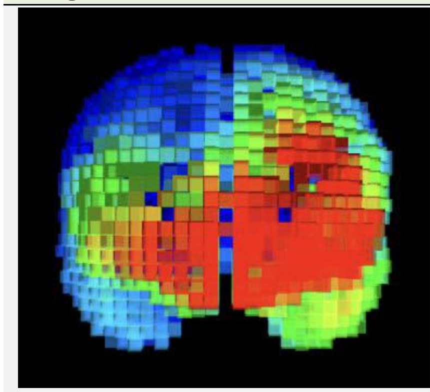
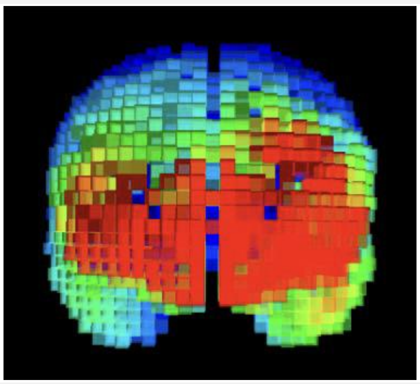
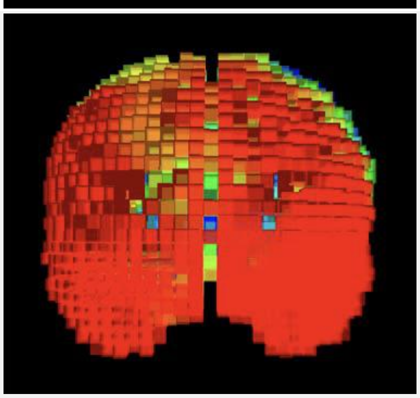
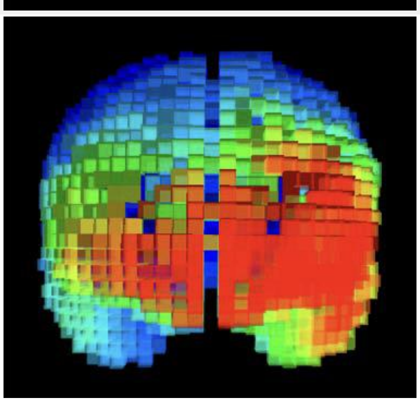
Image	Trigger	Likert Score	Resulting 4x4 Cell
	**Self-guilt**	3	0110 Mixed Feeling
	**Caring for parents**	6	0110 Mixed Feeling
	**Name of victim**	6	1111 Full Activation
	**Gardening**	4	0110 Mixed Feeling + Bad

Table 2
Resulting sLORETA Images

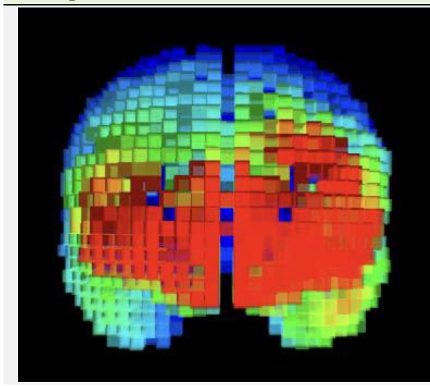
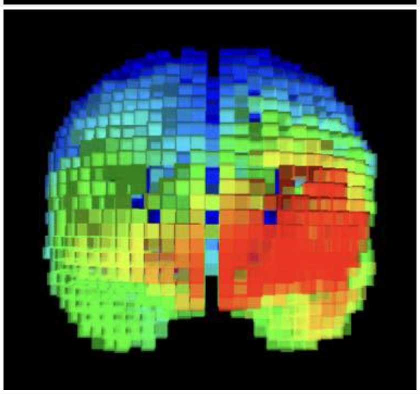
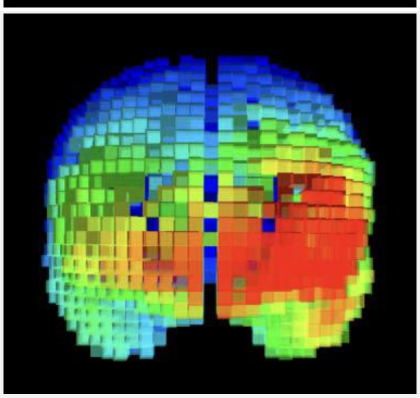
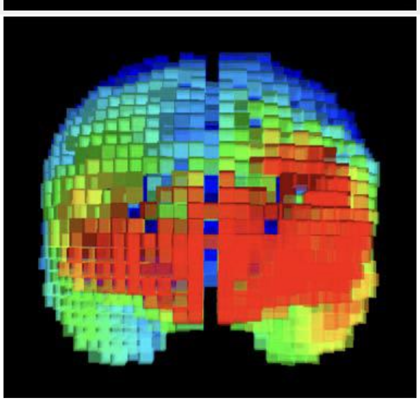
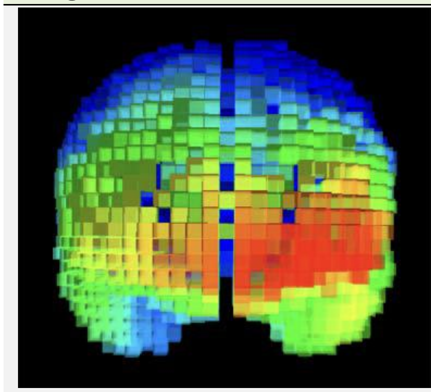
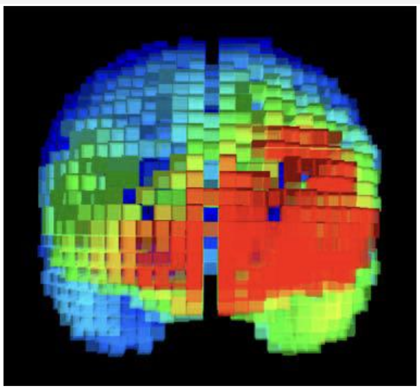
Image	Trigger	Likert Score	Resulting 4x4 Cell
	**Caring for parents**	4	0111 Mixed Feeling + Good
	**Worthlessness**	3	0111 Mixed Feeling + Agree
	**Protecting mother**	4	0111 Mixed Feeling + Good
	**Uncle is coming for mother**	1	0111 Mixed Feeling + Agree

Table 2
Resulting sLORETA Images

Image	Trigger	Likert Score	Resulting 4x4 Cell
	**Protecting family**	5	0110 Mixed Feeling + Agree
	**Uncle is dead**	5	0111 Mixed Feeling + Good

Discussion

The integration of frontal gamma asymmetry using quantitative EEG (qEEG) and current density source localization (sLORETA) provides a novel and compelling method for evaluating emotional processing in forensic contexts, particularly in determining the presence or absence of mens rea, or "guilty mind," in murder cases. In this case study, a structured and repeatable protocol enabled the direct measurement of emotional responses to highly relevant stimuli, offering unique insight into the defendant's internal affective states at the time of the offense. This approach holds significant implications for forensic neuropsychology and legal decision-making.

The results suggest that measures of frontal gamma asymmetry are not only sensitive to emotional valence but may serve as reliable indicators of unconscious or automatic affective responses tied to significant people, memories, or perceived threats. In particular, stimuli involving the victim elicited right frontal gamma asymmetry patterns indicative of an aversive response, while references to parental figures elicited more mixed or positive left-sided activation. These neurophysiological signatures were consistent with the defendant's reported history of protectiveness toward his mother, chronic emotional distress, and reactive traits shaped by environmental trauma and familial conflict. The convergence of these findings with self-report data and behavioral assessments enhances the ecological and construct validity of this forensic methodology (Bonnstetter et al., 2012; Collura et al., 2014a, 2014b).

Interestingly, discrepancies emerged between self-report and informant-based measures on instruments such as the BRIEF-A and ASR: the defendant rated his executive functioning and internalizing symptoms as average, whereas informants described significant difficulties. Such mismatches may reflect limited insight, intentional minimization, or contextual differences between testing environments and daily functioning. These discrepancies underscore the importance of integrating collateral information and highlight how neural metrics may capture implicit affective processes not fully acknowledged in self-report.

Moreover, the documentation of increased alpha activity in BA9 during resting-state EEG suggests a potential neurophysiological substrate for compromised emotional regulation and decision-making. BA9 has been implicated in integrating emotional signals with cognitive control, including reappraisal, inhibition of impulsive behavior, and moral reasoning (Etkin et al., 2011; Goldin et al., 2008; Ochsner & Gross, 2005). Heightened alpha in this region may reflect cortical disengagement or inhibitory gating. However, given evidence that selective serotonin reuptake inhibitors can elevate frontal alpha power, it is important to interpret this finding as correlational and multifactorial rather than as direct evidence of a dual-system breakdown.

The co-occurrence of elevated BA9 alpha power and atypical gamma asymmetry patterns raises the possibility of interactions between top-down and bottom-up processes, but causal mechanisms cannot be established from a single case. High alpha power may attenuate gamma bursts (Scheeringa et al., 2011), thereby influencing emotional processing; conversely, chronic stress, trauma history, and medication effects may also contribute to these patterns. Therefore, any model positing a dual system failure—impaired top-down inhibition via alpha-related disengagement and disorganized bottom-up affective processing via gamma dysregulation—remains speculative. Future research with larger samples and controlled pharmacological conditions is required to clarify these relationships.

This excessive alpha band current density in BA9, nearly four standard deviations increase from the age normed mean in a resting-state condition, is not trivial. Firstly, the alpha frequency band of the EEG, typically defined as oscillatory activity between 8–12 Hz, has long been recognized as more than just a passive indicator of cortical idling. Contemporary research demonstrates that alpha rhythms play an active and organizing role in the regulation of information processing across cortical networks. Rather than reflecting disengagement, alpha oscillations are now understood to support functional inhibition, selectively gating neural resources and modulating the flow of information across brain regions (Jensen & Mazaheri, 2010).

One of the most well-established findings is that increased alpha power in a specific region often correlates with the suppression of task-irrelevant processing, while reduced alpha power is associated with enhanced excitability and readiness in task-relevant regions. For instance, during tasks requiring spatial attention, alpha power increases over parietal-occipital regions contralateral to the unattended visual field, acting as a “neural filter” to inhibit distractions (Foxe & Snyder, 2011). This illustrates how alpha activity is dynamically modulated to organize perception and attention based on behavioral demands. Furthermore, alpha-band synchrony has been implicated in top-down control mechanisms.

Studies using magnetoencephalography (MEG) and EEG show that long-range alpha coherence between prefrontal and posterior cortices is predictive of task performance and cognitive control, supporting the hypothesis that alpha rhythms facilitate large-scale coordination of brain networks (Palva & Palva, 2007). These findings suggest that alpha oscillations help stabilize cortical representations by coordinating when and where information flows during decision-making and working memory operations. Additionally, intracranial and EEG studies have shown that alpha oscillations often precede and predict successful stimulus detection, encoding, and memory retrieval. This temporal alignment implies that alpha rhythms may serve a timing or pacing function, organizing neural activity into cycles that allow for efficient processing of sensory and mnemonic information (Klimesch, 2012).

Importantly, BA9 situated in the dorsolateral prefrontal cortex, plays a central role in the integration of emotional information with cognitive processes. Far from being confined to abstract reasoning or working memory, BA9 is consistently engaged during tasks that require individuals to evaluate, regulate, or act upon emotional stimuli. Its function appears to be critical when emotions must be consciously modulated or weighed in relation to decision-making outcomes (Ochsner & Gross, 2005). Neuroimaging studies have repeatedly shown that BA9 becomes activated during cognitive reappraisal—the process through which individuals reinterpret emotionally charged stimuli to reduce their psychological impact. For example, functional MRI investigations have demonstrated that individuals who successfully downregulate negative affect tend to show heightened activity in right BA9 (Goldin et al., 2008). This suggests that the region is actively recruited to suppress or reshape the salience of negative emotional responses.

Moreover, volumetric studies have revealed that individuals with greater gray matter volume in this region exhibit stronger reappraisal abilities, indicating a structural basis for its role in emotion regulation (Beauregard et al., 2001). Beyond emotion regulation, BA9 is involved in the processing of emotionally relevant information during decision-making tasks. When subjects are faced with risky or emotionally laden choices, BA9 appears to mediate the cognitive strategies that support weighing emotional consequences against long-term goals (Etkin et al., 2011). It is not merely a passive relay but an active processor that helps determine the balance between immediate emotional reactions and deliberate executive functions. In this sense, BA9 acts as a neural fulcrum between impulsivity and foresight (Ochsner & Gross, 2005). Additionally, studies show that BA9 participates in self-reflective emotional processes. When individuals are instructed to introspect about their own emotional states—asking themselves how they feel or why they reacted emotionally—BA9 shows increased activation (Bzdok et al., 2011). This role in self-focused emotional appraisal highlights the region's involvement not only in top-down regulation of emotion but also in the conscious interpretation of internal affective experiences.

Finally, mood induction studies have shown that the function of BA9 is mood sensitive. For example, during working memory tasks, BA9 activity can be enhanced or suppressed depending on whether the participant is in a negative or neutral emotional state, respectively. This illustrates how emotional context influences the recruitment of BA9 even during tasks traditionally considered "cold" cognition (Etkin et al., 2011).

Together, this body of evidence supports the conclusion that BA9 is a critical hub for integrating affective and cognitive processes. It supports the ability to downregulate negative emotion, evaluate emotional consequences, and reflect upon internal emotional states—all of which are essential for adaptive decision-making and emotional resilience.

In the context of mens rea, these findings are significant. Legal determinations of criminal intent often hinge on subjective interpretations of emotional state and motive, which are notoriously difficult to substantiate without external corroboration. The application of EEG-based neurofunctional imaging offers an objective, repeatable, and noninvasive means of validating or challenging claims of temporary insanity, trauma-induced emotional disturbance, or dissociation at the time of an alleged crime. By revealing preconscious emotional reactions to specific stimuli, gamma asymmetry mapping complements traditional forensic interviews and psychometric tools, providing a multidimensional picture of internal state (Bonnstetter et al., 2018; Collura et al., 2016). Furthermore, the refined 4x4 emotional decision model used in this study allows for nuanced categorization of responses—such as mixed feelings with positive or negative judgments—which could be highly informative in legal cases where dichotomous labels like "intentional" or "accidental" may oversimplify complex affective processes. The emotional data obtained via EEG microstates and gamma asymmetry not only substantiates the defendant's reported psychological state but also provides temporal markers of affective reactivity that align with known microstate transitions involved in decision-making (Bonnstetter et al., 2022).

Importantly, this case also highlights key methodological considerations for future applications. Pharmacological influences, such as the subject's use of Zoloft, may modulate baseline neural activity and should be accounted for when interpreting EEG patterns (Goldin et al., 2008). Likewise, habituation effects noted during repeated stimuli exposure suggest the need to limit exposure windows to preserve the emotional salience of trigger stimuli.

While preliminary and limited by its single-case design, this work highlights both the promise and the constraints of integrating neuroscience into forensic practice. Broader applications may extend to evaluating emotional regulation, motive, or credibility, but any suggestion of "emotional lie detection" should be framed cautiously as a potential future research direction rather than an established forensic tool. Ethical considerations and generalizability to diverse populations must also be addressed before such methods can be applied more widely. By demonstrating the feasibility of combining psychological and neurophysiological measures, this study contributes to ongoing interdisciplinary efforts to develop more objective approaches to understanding affect in legal contexts.

Conclusion

Limitations and Ethical Considerations

This evaluation reflects data from a single individual assessed in one setting. There was no behavioral follow-up or replication across sessions, and normative comparisons were based on laboratory samples rather than large epidemiological cohorts. The subject was taking sertraline, which may modulate alpha and gamma activity, and medication-specific norms were unavailable.

Consequently, generalizability is limited, and causal inferences cannot be made. Future research should include larger samples, medication-controlled comparisons, and longitudinal designs.

The application of neural measures in legal contexts also raises important ethical considerations. While EEG-derived metrics may reduce reliance on subjective testimony, there is a risk of overinterpreting ostensibly "objective" data without sufficient empirical validation. Courts must consider the admissibility standards for neuroscientific evidence and the potential for misuse or misinterpretation. Neuroscientific measures should complement rather than replace traditional legal assessments until robust replication and normative databases are established.

In conclusion, our findings suggest that EEG-derived frontal gamma asymmetry and alpha power distribution may hold promise as tools in forensic evaluations of mens rea. Nevertheless, these measures remain experimental and should not be construed as definitive evidence of emotional states or intent. Given the single-case design, medication confounds, and proprietary nature of the gamma protocol, broader forensic utility must await independent replication and multisite validation studies. Neuroscientific evidence should be presented transparently alongside conventional psychological assessments, and its admissibility should be weighed against evolving legal standards and ethical considerations. Until a robust evidence base is established, neurophysiological metrics should complement, not replace, traditional forensic methods.

Author Disclosures

Thomas Collura is the founder and an owner of BrainMaster Technologies, Inc. Ronald Bonnstetter is Executive Director of the Mind Science Center and Vice President of Research for Target Training International. This project was not supported by any grant. AI was not used in the creation of the content in this manuscript. Authors accept responsibility for the accuracy of reported data and findings.

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