NeuroTrace Study Guide

Domain: Domain I – Basic Concepts & Principles
Section: Neuroanatomy for EEG Localization
Style: Point-form, EEG-centric, exam-oriented
Avoid: Pure memorization anatomy

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1. Core Principles (Must Know)

EEG Signal Source

- EEG reflects **cortical pyramidal neuron activity**
- Deep brain structures are **not directly recorded** on scalp EEG
- Only cortical activity generates detectable scalp potentials

Localization Depends On

- **Cortical region** (lobar anatomy)
- **Orientation of neurons** (perpendicular to scalp = best signal)
- **Skull/scalp attenuation** (affects amplitude and field distribution)

Key Principle

- **EEG is a map of cortical function, not whole-brain anatomy**
- Subcortical structures influence EEG indirectly through cortical connections
- Deep lesions may cause diffuse or generalized changes, not focal EEG findings

Practical Application

- Focal EEG abnormalities → cortical pathology
- Generalized abnormalities → may be cortical or subcortical origin
- Always correlate EEG with clinical presentation and imaging

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2. Cerebral Lobes & EEG Correlates

Frontal Lobe

Function

- Executive function
- Motor planning
- Behavioral regulation
- Working memory

EEG Findings

- **Frontal intermittent rhythmic delta activity (FIRDA)**
- Focal frontal slowing (theta/delta)
- Frontal sharp waves/spikes
- Frontal beta activity (motor cortex)

Clinical Correlation

- **Behavioral changes** (personality, executive dysfunction)
- **Motor seizures** (tonic, clonic, hypermotor)
- Frontal lobe epilepsy (often nocturnal)

- Encephalopathy with frontal predominance

ABRET Emphasis

- Frontal slowing often bilateral but may be asymmetric
- FIRDA suggests deep midline or diffuse dysfunction
- Frontal spikes may be subtle and require sleep

Temporal Lobe

Function

- Memory (hippocampus)
- Language (dominant hemisphere)
- Auditory processing
- Emotion (amygdala)

EEG Findings

- **Temporal sharp waves** (most common focal epileptiform)
- Rhythmic theta/delta (temporal slowing)
- Temporal spikes
- Temporal intermittent rhythmic delta activity (TIRDA)

Clinical Correlation

- **Memory impairment**
- **Language deficits** (if dominant hemisphere)
- **Focal impaired awareness seizures**
- Temporal lobe epilepsy (most common focal epilepsy)

ABRET Emphasis

- **Temporal lobe epilepsy is the most common focal epilepsy**
- Temporal sharp waves are high-yield pattern
- May require sleep or special electrodes (T1/T2, sphenoidal) to detect
- Mesial temporal sclerosis is common cause

Parietal Lobe

Function

- Sensory integration
- Spatial awareness
- Calculation
- Reading

EEG Findings

- **Subtle focal slowing** (often poorly localized)
- Parietal spikes (less common)
- Frequently underrepresented on scalp EEG

Clinical Correlation

- Sensory seizures (paresthesias)
- Spatial neglect
- Gerstmann syndrome (if dominant hemisphere)

ABRET Trap

- Parietal abnormalities are often **poorly localized**
- May appear as "generalized" or "multifocal"
- Require careful montage analysis for localization

Occipital Lobe

Function

- Visual processing
- Visual recognition

EEG Findings

- **Posterior dominant rhythm (PDR)** (normal alpha)
- Occipital spikes/sharp waves
- Occipital slowing
- **Photic sensitivity relevance** (occipital cortex responds to photic)

Clinical Correlation

- Visual seizures (auras, hallucinations)
- Visual field defects
- Occipital lobe epilepsy
- Photosensitive epilepsy

ABRET Emphasis

- PDR is normal finding (8-13 Hz in adults)
- Occipital spikes may be benign (especially in children)
- Photic stimulation activates occipital cortex
- Must differentiate normal PDR from occipital pathology

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3. Hemispheric Lateralization

Unilateral Abnormalities

- **Focal pathology** (structural lesion, focal epilepsy)
- Asymmetric slowing suggests focal cortical dysfunction
- Lateralized spikes/sharp waves indicate focal irritability

Bilateral with Asymmetry

- **Focal dominance** (one hemisphere more affected)
- May indicate:
    - Unilateral lesion with contralateral effects
    - Bilateral process with asymmetric severity
    - Secondary generalization from focal onset

Generalized Patterns

- **Diffuse or subcortical processes**
- Metabolic/toxic encephalopathy
- Generalized epilepsy
- Deep midline dysfunction

Exam Trap

- **Asymmetric generalized slowing ≠ focal lesion automatically**

- May be:
  - Diffuse process with asymmetry
  - Technical artifact (electrode placement, impedance)
  - Normal variant (asymmetric alpha)
- Always correlate with clinical findings

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4. Cortical vs Subcortical Patterns

Pattern	Likely Source	EEG Characteristics
Focal slowing	Cortical lesion	Theta/delta over specific lobe(s)
Generalized slowing	Metabolic/toxic	Diffuse theta/delta, symmetric
FIRDA	Deep midline / diffuse dysfunction	Frontal intermittent rhythmic delta
Burst-suppression	Severe global dysfunction	Alternating bursts and suppression
Focal spikes	Cortical irritability	Sharp waves over specific region
Generalized spikes	Diffuse or subcortical	Bilateral synchronous spikes

Key Distinctions

Cortical Patterns

- **Focal** (localized to specific lobe)
- **Asymmetric** (one hemisphere affected)
- **Sharp/spiky morphology** (epileptiform)
- Correlate with structural lesions

Subcortical Patterns

- **Generalized** (bilateral, symmetric)
- **Diffuse slowing** (not focal)
- **Metabolic patterns** (triphasic waves, burst-suppression)
- May not show focal EEG changes

ABRET Application

- Given EEG pattern → identify likely source (cortical vs subcortical)
- Given clinical presentation → predict EEG pattern
- Understand why deep lesions may not show focal EEG changes

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5. Pediatric Considerations

Incomplete Myelination

- Alters EEG appearance
- More slow activity is normal in children
- Background frequencies increase with age
- PDR frequency matures with age

Localization Less Precise

- **Young children:** EEG fields are broader

- **Infants:** Multifocal patterns are common
- **Toddlers:** Localization improves but still less precise than adults

Normal Variants Can Mimic Pathology

- **Rolandic spikes** (benign, central-temporal)
- **Occipital spikes** (benign, especially in children)
- **Frontal sharp transients** (normal sleep pattern)
- Must know age-appropriate norms

ABRET Trap

- **Do not over-localize pediatric EEG findings**
- Multifocal spikes in children may be normal variant
- Always consider age when interpreting localization
- Pediatric EEG requires different localization criteria

Age-Specific Localization

- **Neonates:** Very broad fields, multifocal common
- **Infants (0-1 year):** Localization improving but still broad
- **Children (2-12 years):** Better localization, but variants common
- **Adolescents/Adults:** Precise localization possible

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6. Common ABRET Exam Traps

Trap 1: Assuming Deep Lesions Produce Focal EEG Changes

- **Reality:** Deep structures (thalamus, basal ganglia) may cause generalized or no focal changes
- Deep lesions affect cortex diffusely through connections
- Don't expect focal EEG from deep pathology

Trap 2: Over-Localizing Poorly Formed Slowing

- **Reality:** Subtle slowing may be poorly localized
- Parietal and deep frontal slowing often appear "generalized"
- Not all slowing can be precisely localized

Trap 3: Ignoring State (Sleep vs Wake)

- **Reality:** Localization varies with state
- Some patterns only appear in sleep
- Sleep activates certain regions (frontal, temporal)
- Always note state when localizing

Trap 4: Forgetting Age-Related EEG Differences

- **Reality:** Pediatric EEG has different localization rules
- Children have broader fields, more multifocal patterns
- Normal variants can mimic pathology
- Always consider age when localizing

Trap 5: Not Correlating with Clinical Presentation

- **Reality:** EEG localization must match clinical findings
- Temporal spikes + memory problems = temporal lobe epilepsy
- Frontal slowing + behavioral changes = frontal dysfunction
- Always correlate EEG with clinical presentation

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7. Case-Based Example

Scenario

Clinical Presentation: 35-year-old with focal impaired awareness seizures
EEG Finding: Left temporal sharp waves, maximum at T7
Clinical History: Memory problems, déjà vu episodes

Interpretation

- **EEG suggests:** Left temporal cortical irritability
- **Localization:** Left temporal lobe (dominant hemisphere)
- **Clinical correlation:** Matches seizure semiology (memory, déjà vu)

Next Step

1. **Correlate with seizure semiology** (focal impaired awareness = temporal)
2. **Consider imaging** (MRI to look for mesial temporal sclerosis)
3. **Document localization** in technical report
4. **Note clinical correlation** (memory problems support temporal localization)

Teaching Point

- **EEG localization must always be clinically correlated**
- Temporal sharp waves + temporal seizure semiology = strong correlation
- Isolated EEG finding without clinical correlation is less meaningful
- Always integrate EEG, clinical, and imaging findings

ABRET Application

- Given EEG pattern → predict clinical presentation
- Given clinical presentation → predict EEG pattern
- Understand why correlation is essential for accurate interpretation

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8. Exam Readiness Checklist

Use this checklist to verify your understanding:

- [ ] Can identify lobar EEG correlates (frontal, temporal, parietal, occipital)
- [ ] Can localize focal slowing to specific lobes
- [ ] Can differentiate cortical vs subcortical processes
- [ ] Can apply pediatric considerations to localization
- [ ] Understand that EEG reflects cortical activity, not deep structures
- [ ] Know that temporal lobe epilepsy is most common focal epilepsy
- [ ] Recognize that parietal abnormalities are often poorly localized
- [ ] Understand that focal slowing usually indicates cortical pathology
- [ ] Can identify ABRET exam traps related to localization
- [ ] Know that EEG localization must be clinically correlated

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9. Internal Cross-Links

Patterns

- **Focal Slowing:** Requires understanding of lobar anatomy for localization
- **Epileptiform Discharges:** Temporal sharp waves are most common focal pattern
- **Normal Variants:** Must know age-appropriate patterns to avoid false localization

Workflow

- **Electrode Placement (10–20):** Understanding electrode positions relative to brain anatomy
- **Montages:** Montage selection affects localization accuracy
- **Pattern Recognition:** Localization depends on pattern identification

Cases

- **Localization-based EEG cases:** Cases involving focal slowing, focal epileptiform activity
- **Pediatric localization cases:** Cases requiring age-appropriate interpretation
- **Clinical correlation cases:** Cases requiring integration of EEG and clinical findings

Quizzes

- **Neuroanatomy & Localization MCQs:** Questions on lobar correlates, cortical vs subcortical
- **Localization prediction:** Given pattern, identify likely brain region
- **Clinical correlation:** Given clinical presentation, predict EEG pattern

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Study Tips

1. **Focus on EEG-relevant anatomy:** Don't memorize everything, just what affects EEG
2. **Learn lobar correlates:** Each lobe has characteristic EEG patterns
3. **Understand cortical vs subcortical:** Key distinction for ABRET
4. **Remember pediatric differences:** Localization rules change with age
5. **Always correlate:** EEG localization must match clinical presentation
6. **Practice pattern recognition:** Localization depends on identifying patterns correctly
7. **Know the traps:** Deep lesions don't always show focal changes

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End of Study Guide

For additional practice, complete quiz questions tagged: frontal, temporal, parietal, occipital, focal-slowing, lateralization