NeuroTrace Study Guide

Domain: Domain II – EEG Procedures & Instrumentation
Section: Montages & Referencing
Style: Applied, localization-focused, ABRET-oriented

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1. Core Concepts (Must Know)

Signal Display

- **EEG displays voltage differences** between electrodes
- Not absolute voltage, but relative differences
- Montage determines which electrodes are compared
- Same signal appears differently in different montages

Montage Determines

- **Polarity** (which direction signal deflects)
- **Amplitude distribution** (how large signals appear)
- **Apparent localization** (where activity appears maximal)
- **Artifact behavior** (how artifacts appear)

Key Principle

- **Montage does not change brain activity, only how it is displayed**
- Same cerebral activity looks different in different montages
- Must use multiple montages for accurate interpretation
- Montage selection affects what you can see

Practical Application

- Always review EEG in multiple montages
- Compare findings across montages before concluding
- Understand how montage affects appearance
- Use appropriate montage for specific questions

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2. Common EEG Montages

Longitudinal Bipolar

Structure

- **Electrodes linked anterior → posterior**
- Chain of connections along same hemisphere
- Example: Fp1-F3, F3-C3, C3-P3, P3-O1
- Creates "chain" of connections

Good For

- **Phase reversal** (localization of focal activity)
- **Lateralization** (left vs right comparison)
- **Artifact identification** (artifacts behave differently)
- **Focal abnormalities** (clear phase reversals)

Characteristics

- Clear phase reversals at focal sites

- Good for lateralization
- Less affected by reference contamination
- Standard for routine EEG

Transverse Bipolar

Structure

- **Electrodes linked left → right**
- Connections across hemispheres
- Example: Fp1-Fp2, F3-F4, C3-C4, P3-P4
- Highlights asymmetry

Good For

- **Asymmetry detection** (left vs right comparison)
- **Lateralized abnormalities** (unilateral findings)
- **Hemispheric comparison** (side-to-side differences)
- **Artifact discrimination** (lateralized artifacts)

Characteristics

- Excellent for asymmetry
- Highlights lateralized findings
- Less useful for precise localization
- Good complement to longitudinal bipolar

Referential

Structure

- **Each electrode compared to a common reference**
- Reference may be: linked ears, average, Cz, etc.
- Example: Fp1-A1, F3-A1, C3-A1, P3-A1
- All channels share same reference

Good For

- **Absolute amplitude** (true amplitude at each electrode)
- **Focal abnormalities** (clear amplitude at focal site)
- **Widespread activity** (generalized patterns)
- **Reference-independent findings** (if reference is "quiet")

Characteristics

- Shows true amplitude at each electrode
- Affected by reference contamination
- Good for focal abnormalities
- Requires "quiet" reference

Average Reference

Structure

- **Each electrode compared to average of all electrodes**
- Reference = average of all active electrodes
- Example: Fp1-AVG, F3-AVG, C3-AVG, P3-AVG
- Reference is calculated, not physical electrode

Good For

- **Focal abnormalities** (if widespread activity)

- **Generalized patterns** (reduces reference contamination)
- **Research applications** (standardized reference)
- **Complex localization** (multiple focal sites)

Characteristics

- Reduces reference contamination
- Good for focal abnormalities
- May mask widespread activity
- Requires all electrodes functioning

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3. Phase Reversal

Definition

- **Occurs when polarity changes between adjacent channels**
- Upward deflection in one channel, downward in adjacent
- Indicates site of maximal voltage difference
- Localizes focal abnormality

Mechanism

- Focal activity creates voltage gradient
- Maximum voltage at focal site
- Polarity reverses at site of maximum
- Phase reversal marks the focal site

ABRET Emphasis

- **Phase reversal helps localize focal abnormalities**
- Must identify phase reversal in bipolar montages
- Phase reversal indicates site of maximum activity
- Critical for accurate localization

Recognition

- Look for polarity change between adjacent channels
- Phase reversal occurs at site of maximum activity
- Must be in bipolar montage (not referential)
- Compare with referential montage for confirmation

Clinical Application

- Focal spikes show phase reversal
- Focal slowing may show phase reversal
- Phase reversal localizes epileptiform activity
- Essential for surgical planning

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4. Reference Contamination

Definition

- **Reference electrode contains cerebral activity**
- Reference is not truly "inactive"
- Reference activity affects all channels
- Can mask or create false abnormalities

Effects

- **Can mask abnormalities** (if reference has similar activity)
- **Can create false localization** (if reference has focal activity)
- **Can obscure findings** (if reference is contaminated)
- **Affects all referential channels** (all share same reference)

ABRET Trap

- **A "quiet" reference is rarely truly inactive**
- Even "quiet" references may have some activity
- Reference contamination is common
- Must consider reference when interpreting referential montages

Common References

Linked Ears (A1-A2)

- Often used but may be contaminated
- Ear electrodes may pick up temporal activity
- Can mask temporal abnormalities
- Not truly "quiet"

Average Reference

- Calculated from all electrodes
- Reduces but doesn't eliminate contamination
- Good for focal abnormalities
- May mask widespread activity

Cz Reference

- Central electrode as reference
- May be contaminated by central activity
- Good for some applications
- Not ideal for central abnormalities

Best Practice

- Use bipolar montages to reduce reference effects
- Compare referential with bipolar findings
- Understand that no reference is perfect
- Consider reference contamination in interpretation

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5. Montage Comparison Strategy

Always Review EEG In

- **Bipolar montage** (longitudinal and/or transverse)
- **Referential montage** (at least one type)
- **Compare findings** before concluding localization
- **Use multiple montages** for confirmation

Comparison Process

1. **Identify abnormality in one montage**
2. **Check same abnormality in other montages**
3. **Compare localization** across montages

4. **Confirm findings** are consistent
5. **Interpret** only after montage comparison

True Abnormalities

- **Persist across montages** (appear in multiple montages)
- **Show consistent localization** (same location in different montages)
- **Have appropriate morphology** (consistent appearance)
- **Correlate with clinical findings**

Artifacts

- **May change with montage** (different appearance)
- **May disappear in some montages** (montage-dependent)
- **May show inconsistent localization** (different locations)
- **Do not correlate with clinical findings**

Clinical Application

- Epileptiform discharges appear in multiple montages
- True slowing persists across montages
- Artifacts often change with montage
- Montage comparison helps distinguish artifact from pathology

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6. Common ABRET Exam Traps

Trap 1: Over-Reliance on a Single Montage

- **Reality:** Must use multiple montages for accurate interpretation
- Single montage may miss or mislocalize abnormalities
- Always compare findings across montages
- No single montage is perfect

Trap 2: Misinterpreting Polarity Without Context

- **Reality:** Polarity depends on montage and electrode position
- Upward deflection doesn't always mean negative
- Must understand montage structure to interpret polarity
- Context is essential for polarity interpretation

Trap 3: Ignoring Reference Contamination

- **Reality:** Reference contamination is common
- Can mask or create false abnormalities
- Must consider reference when using referential montages
- Bipolar montages reduce reference effects

Trap 4: Confusing Artifact for Phase Reversal

- **Reality:** Artifacts can create apparent phase reversals
- Must verify phase reversal in multiple montages
- Artifacts often change with montage
- True phase reversal is consistent across montages

Trap 5: Not Comparing Montages

- **Reality:** Must compare findings across montages
- Single montage interpretation is incomplete

- Comparison confirms true abnormalities
- Always use multiple montages for localization

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7. Clinical Correlation

Epileptiform Discharges

- **Localize best when seen across multiple montages**
- Phase reversal in bipolar montages
- Clear amplitude in referential montages
- Consistent localization across montages

Artifact Behavior

- **Often changes with montage selection**
- May appear in one montage but not others
- May show inconsistent localization
- Montage comparison helps identify artifacts

Focal Abnormalities

- **Require montage comparison for accurate localization**
- Phase reversal localizes site of maximum
- Referential montage confirms focal nature
- Multiple montages increase confidence

Best Practice

- Always use multiple montages
- Compare findings across montages
- Understand how montage affects appearance
- Use appropriate montage for specific questions

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8. Case-Based Example

Scenario

Clinical Setting: Routine EEG for seizure evaluation
Bipolar Montage Finding: Spike appears maximal at F7
Clinical Question: Is this a true temporal spike?

Montage Comparison

- **Bipolar montage:** Phase reversal at F7-T3
- **Referential montage:** Clear spike at F7, smaller at T3
- **Transverse bipolar:** Asymmetric, left greater than right
- **All montages confirm:** Focal left temporal spike

Interpretation

- **True epileptiform activity** (persists across montages)
- **Localized to left temporal region** (consistent across montages)
- **Phase reversal confirms** focal nature
- **Referential montage confirms** amplitude and distribution

Teaching Point

- **True epileptiform activity persists across montages**
- Must compare findings across montages
- Phase reversal helps localize
- Multiple montages increase diagnostic confidence

ABRET Application

- Given finding in one montage → check other montages
- Given phase reversal → identify site of maximum
- Given referential finding → compare with bipolar
- Understand that montage comparison is essential

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9. Exam Readiness Checklist

Use this checklist to verify your understanding:

- ☐ Can explain montage purpose (how electrodes are compared)
- ☐ Can identify phase reversal (polarity change between channels)
- ☐ Can localize abnormalities (using phase reversal and amplitude)
- ☐ Can recognize reference contamination (reference activity affecting channels)
- ☐ Understand that same signal looks different in different montages
- ☐ Know that montage doesn't change brain activity, only display
- ☐ Recognize that phase reversal localizes site of maximum voltage
- ☐ Understand that true abnormalities persist across montages
- ☐ Know that artifacts often change with montage
- ☐ Can identify ABRET exam traps related to montages

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10. Internal Cross-Links

Workflow

- **Electrode Placement (10–20):** Proper placement essential for montages
- **Instrumentation Overview:** Montages are part of instrumentation
- **Localization:** Montages are essential for localization

Patterns

- **Epileptiform Discharges:** Require montage comparison for localization
- **Polarity & Phase:** Phase reversal is key to localization
- **Focal Abnormalities:** Montages essential for focal findings

Cases

- **Montage comparison cases:** Cases teaching montage interpretation
- **Localization cases:** Cases requiring montage analysis
- **Artifact vs cerebral activity:** Cases using montage comparison

Quizzes

- **Montage & referencing MCQs:** Questions on montage types, phase reversal
- **Localization questions:** Questions requiring montage knowledge

- **Polarity interpretation:** Questions on phase reversal and polarity

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Study Tips

1. **Memorize montage types:** Bipolar (longitudinal, transverse), referential, average
2. **Understand phase reversal:** Polarity change localizes maximum activity
3. **Learn reference contamination:** Reference activity affects all channels
4. **Practice comparison:** Always compare findings across montages
5. **Remember the principle:** Montage affects display, not brain activity
6. **Know the traps:** Over-reliance on single montage, ignoring reference contamination
7. **ABRET focus:** Expect questions on phase reversal, montage behavior, reference contamination

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End of Study Guide

For additional practice, complete quiz questions tagged: montage, referencing, phase-reversal, polarity, localization