NeuroTrace Study Guide

Domain: Domain II – EEG Procedures & Instrumentation
Section: Electrodes & Impedance
Style: Point-form, applied, exam-oriented

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1. Core Concepts (Must Know)

Signal Detection

- EEG electrodes detect **voltage differences**, not absolute voltage
- Electrodes measure potential difference between two points
- Common reference allows comparison across channels

Signal Quality Depends On

- **Electrode contact** (skin-electrode interface)
- **Impedance balance** (equal impedance across electrodes)
- **Skin preparation** (removal of oils, dead skin, hair products)
- **Electrode material** (affects stability and noise)

Impedance Definition

- Impedance reflects **resistance + capacitance**
- Measured in ohms (Ω)
- Represents opposition to electrical flow
- Includes skin resistance and electrode-skin interface

Key Principle

- **Low and balanced impedance improves signal-to-noise ratio**
- More important than absolute value: **impedance balance**
- Unequal impedance creates artifacts and noise
- High impedance increases susceptibility to interference

Practical Application

- Always check impedance before recording
- Re-check impedance if artifacts appear
- Balance impedance across all electrodes
- Document impedance values in technical report

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2. EEG Electrode Types

Common Materials

Silver–Silver Chloride (Ag/AgCl) – Preferred

- **Most stable recordings**
- Low noise characteristics
- Good for long-term recordings
- Standard for clinical EEG

Gold

- Good conductivity

- Less stable than Ag/AgCl
- May require more frequent reapplication
- Used in some specialized applications

Tin

- Adequate for short recordings
- Less stable than Ag/AgCl
- May have higher noise
- Less commonly used in modern EEG

ABRET Emphasis

- **Ag/AgCl electrodes provide the most stable recordings**
- Preferred material for clinical EEG
- Understand why material choice matters

Electrode Forms

Cup Electrodes

- Reusable or disposable
- Applied with conductive paste or gel
- Most common in clinical EEG
- Allow for impedance measurement

Disposable Electrodes

- Pre-gelled, single-use
- Convenient but may have higher impedance
- Good for quick setups
- May not allow impedance measurement

Needle Electrodes (Limited EEG Use)

- Inserted subcutaneously
- Lower impedance but invasive
- **Safety note:** Increase infection risk
- Rarely used in routine EEG
- Reserved for special circumstances

Safety Considerations

- **Needle electrodes increase infection risk**
- Require sterile technique
- Contraindicated in patients with bleeding disorders
- Must follow infection control protocols

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3. Understanding Impedance

Measurement

- Measured in **ohms (Ω)**
- Represents opposition to electrical flow
- Includes both resistance and capacitance components

Components of Impedance

- **Skin resistance** (primary component)

- **Electrode-skin interface** (contact quality)
- **Electrode material** (affects interface)
- **Conductive paste/gel** (reduces impedance)

Typical Acceptable Ranges

Preferred: ≤ 5 kΩ

- Optimal signal quality
- Minimal artifact
- Best for clinical interpretation
- Standard for most recordings

Acceptable: ≤ 10 kΩ

- Adequate for most purposes
- May have slightly increased noise
- Acceptable if balanced across electrodes
- May require more frequent monitoring

Unacceptable: > 10 kΩ

- Increased artifact risk
- Poor signal quality
- May mask true cerebral signals
- Requires immediate correction

Critical Point

- **More important than absolute value: impedance balance**
- Unequal impedance is worse than uniformly high impedance
- Balance reduces common-mode noise
- Always check for impedance balance

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4. Impedance Balance vs Absolute Value

Balanced Impedance Reduces

- **Common-mode noise** (noise affecting all channels equally)
- **60 Hz interference** (power line noise)
- **Artifact propagation** (artifacts spreading across channels)
- **Baseline drift** (unstable recordings)

Unequal Impedance Increases Artifact

- **60 Hz interference** (especially with unequal impedance)
- **Electrode pop** (sudden impedance changes)
- **Drift** (unstable electrode interface)
- **Channel-specific noise** (affecting only high-impedance channels)

ABRET Trap

- **Low impedance alone does NOT guarantee artifact-free EEG**
- Must also have **balanced impedance**
- Can have low impedance but still have artifacts if unbalanced
- Always check both absolute value and balance

Practical Application

- Check impedance of all electrodes
- Ensure all electrodes are within acceptable range
- Verify impedance is balanced (similar values across electrodes)
- Re-check if artifacts appear during recording

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5. Impedance-Related Artifacts

Artifact	Likely Cause	Solution
60 Hz interference	High or unequal impedance	Lower impedance, balance electrodes
Electrode pop	Poor contact or drying paste	Re-prep skin, reapply electrode
Drift	Unstable electrode interface	Improve contact, check paste
Excess noise	Inadequate skin prep	Clean skin, remove oils
Baseline shift	Impedance changes during recording	Re-check impedance, reapply electrode
Channel-specific artifact	One electrode with high impedance	Fix that specific electrode

Recognition Tips

- **60 Hz:** Regular 60 Hz oscillations, often in one channel
- **Electrode pop:** Sudden, brief deflections, often repetitive
- **Drift:** Slow baseline movement, not cerebral in origin
- **Excess noise:** High-frequency noise, obscures cerebral activity

ABRET Application

- Given artifact → identify likely impedance cause
- Given impedance values → predict likely artifacts
- Understand why impedance matters for artifact prevention

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6. Common ABRET Exam Traps

Trap 1: Believing Impedance of 0 is Ideal

- **Reality:** Some impedance is normal and expected
- Very low impedance may indicate bridging (electrodes touching)
- Target is ≤ 5 kΩ, not zero
- Zero impedance suggests technical problem

Trap 2: Ignoring Impedance Balance

- **Reality:** Balance is more important than absolute value
- Unequal impedance causes more problems than uniformly high impedance
- Always check for balance, not just individual values
- One high-impedance electrode can affect entire recording

Trap 3: Confusing Impedance with Sensitivity

- **Reality:** These are independent settings
- **Impedance** affects signal quality and artifact
- **Sensitivity** affects amplitude display (μV/mm)

- Don't confuse signal quality with amplitude settings

Trap 4: Assuming Digital EEG Corrects Poor Electrode Contact

- **Reality:** Digital EEG still requires good electrode contact
- Digital systems may mask some artifacts but cannot fix poor contact
- Always verify impedance, even with digital systems
- Good technique is essential regardless of system type

Trap 5: Not Re-Checking Impedance During Recording

- **Reality:** Impedance can change during recording
- Paste can dry, electrodes can shift, skin can sweat
- Re-check impedance if artifacts appear
- Document impedance checks in technical report

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7. Clinical Correlation

Poor Impedance Can

- **Mimic epileptiform activity** (electrode pop can look like spikes)
- **Mask true cerebral signals** (noise obscures real activity)
- **Create false abnormalities** (artifacts mistaken for pathology)
- **Reduce diagnostic yield** (poor quality limits interpretation)

Pediatric and Agitated Patients

- **Require frequent rechecks** (movement disrupts contact)
- May have higher baseline impedance (smaller head, more movement)
- Need careful skin prep (may be more difficult)
- May require more frequent electrode reapplication

Best Practice

- Check impedance at start of recording
- Re-check if artifacts appear
- Document impedance values
- Balance impedance across all electrodes
- Verify impedance before interpreting abnormalities

Clinical Impact

- Poor impedance → poor signal quality → limited interpretation
- Artifacts from poor impedance can lead to misdiagnosis
- Good impedance technique is essential for quality EEG
- Always verify technical quality before clinical interpretation

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8. Case-Based Example

Scenario

Clinical Setting: Routine EEG recording
EEG Finding: Excessive 60 Hz noise in one channel (T7)
Other Channels: Normal, minimal artifact
Impedance Check: Not performed initially

Hidden Issue

- **One electrode (T7) impedance significantly higher than others**
- T7 impedance: 25 kΩ (unacceptable)
- Other electrodes: 3-5 kΩ (acceptable)
- Unequal impedance causing 60 Hz interference in T7 channel

Correct Action

1. **Re-prep skin** at T7 location (clean thoroughly)
2. **Reapply electrode** with fresh conductive paste
3. **Re-check impedance** (should be ≤ 5 kΩ)
4. **Verify artifact resolved** (60 Hz noise should disappear)
5. **Document** impedance values and corrective action

Teaching Point

- **Always verify impedance before interpreting abnormalities**
- 60 Hz artifact in one channel suggests impedance problem
- Unequal impedance is common cause of channel-specific artifacts
- Good technique prevents artifacts and improves diagnostic yield

ABRET Application

- Given artifact pattern → identify likely cause (impedance)
- Given impedance values → predict likely artifacts
- Understand corrective actions for impedance problems
- Know when to re-check impedance during recording

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9. Exam Readiness Checklist

Use this checklist to verify your understanding:

- ☐ Can identify EEG electrode types and materials (Ag/AgCl, gold, tin)
- ☐ Can explain impedance vs resistance (impedance includes capacitance)
- ☐ Can recognize impedance-related artifacts (60 Hz, electrode pop, drift)
- ☐ Can apply safe impedance limits (≤ 5 kΩ preferred, ≤ 10 kΩ acceptable)
- ☐ Understand that impedance balance is more important than absolute value
- ☐ Know that Ag/AgCl electrodes provide most stable recordings
- ☐ Recognize that unequal impedance increases artifact
- ☐ Understand that poor impedance can mimic epileptiform activity
- ☐ Know that pediatric patients require frequent impedance rechecks
- ☐ Can identify ABRET exam traps related to impedance

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10. Internal Cross-Links

Workflow

- **Electrode Placement (10–20 System):** Proper placement affects impedance
- **Instrumentation & Display Settings:** Impedance affects signal quality
- **Artifacts & Troubleshooting:** Impedance is common artifact source

Standards

- **Technical Quality Requirements:** Impedance standards and documentation
- **ACNS Guidelines:** Impedance recommendations for quality EEG
- **ABRET Competencies:** Impedance management expectations

Patterns

- **Artifacts:** Impedance-related artifacts (60 Hz, electrode pop, drift)
- **Normal Patterns:** Good impedance required to see normal activity clearly
- **Epileptiform Activity:** Must distinguish from impedance artifacts

Cases

- **Technical artifact simulations:** Cases involving impedance problems
- **Pediatric setup challenges:** Cases requiring impedance management
- **Artifact recognition:** Cases teaching artifact vs pathology

Quizzes

- **Electrode & impedance MCQs:** Questions on materials, impedance limits, artifacts
- **Artifact identification:** Questions on recognizing impedance-related artifacts
- **Technical troubleshooting:** Questions on corrective actions

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Study Tips

1. **Memorize impedance limits:** ≤ 5 kΩ preferred, ≤ 10 kΩ acceptable
2. **Understand balance vs absolute value:** Balance is more important
3. **Learn artifact recognition:** 60 Hz, electrode pop, drift patterns
4. **Know electrode materials:** Ag/AgCl is preferred
5. **Practice troubleshooting:** Given artifact, identify impedance cause
6. **Remember safety:** Needle electrodes increase infection risk
7. **ABRET focus:** Expect questions on impedance limits, balance, and artifacts

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End of Study Guide

For additional practice, complete quiz questions tagged: impedance, electrodes, artifact, noise, signal-quality