HYBRID NEURO

How to improve the EMG acquisition: quality control for MU identification

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Motivation

- Signals we will have a look at:
  - Intentionally using screenshots of signals from the live stream
    - This is how we usually do quality checks
  - Equipment used:
    - Quattrocento - acquisition from battery
    - Sampling frequency: 2048 Hz
    - Tibialis Anterior with 64-channel electrode (GR08MM1305)
    - Pat Ref and Pre-Amp Ref on ankle
    - Monopolar
    - Bandpass filter (10-500 Hz)

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Motivation

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Instructions to participants

- Shave the area of electrode application
  - Avoid using shaving foams
- Don’t use any body lotions, creams, … (cosmetic products)
  - Can cause unexplainable *“noise”* or *“flat”* EMGs
  - It acts as a thin, nonconductive layer
- Don’t drink coffee before measurements
  - Can affect the firing frequency of MUs

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Setup and what we should pay attention to

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- Try isolating the participant from being in contact with metal
  - Metal rigs, metal chair, …
  - Not always possible
- Identify possible noise sources
  - A/C, fluorescent lamp, refrigerator, …
  - MRI (medical environment)
- Power all measurement devices from the same power phase
  - Use the power extension cord
  - Eliminates potential noise from interphase voltage

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Setup and what we should pay attention to

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Skin preparation

- Shave the skin
  - Removing hair will improve electrode adhesion
  - Hair can cause interelectrode contact
- Clean the target area with abrasive gel – for better conductance
  - Scrubbing the skin removes the dead skin cells and other impurities from the skin's surface
  - If possible, avoid using alcohol for cleaning because it can dry the skin
  - Be careful with the amount of applied pressure when scrubbing
- Pay attention to extensive cleaning (if possible, use isopropyl alcohol):
  - In case cosmetic products were used – particularly female participants
  - If ultrasound gel was used

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Electrode preparation

- Inspect the electrode for oxidation
- Carefully align and apply the adhesive foam to the electrode
- Firmly press the adhesive foam to the electrode
  - Prevents the conductive paste from getting underneath the foam
  - Can cause interelectrode contact
- Apply the conductive paste - *how?*
  - Pay attention to air bubbles - push the conductive paste into the holes
  - *What can happen in a hot environment?*
  - Carefully remove the adhesive foam protective layer
- Using conductive gel instead of conductive paste
  - *What happens to gel after 1-2 hours? What happens to gel in a hot environment?*

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Electrode preparation

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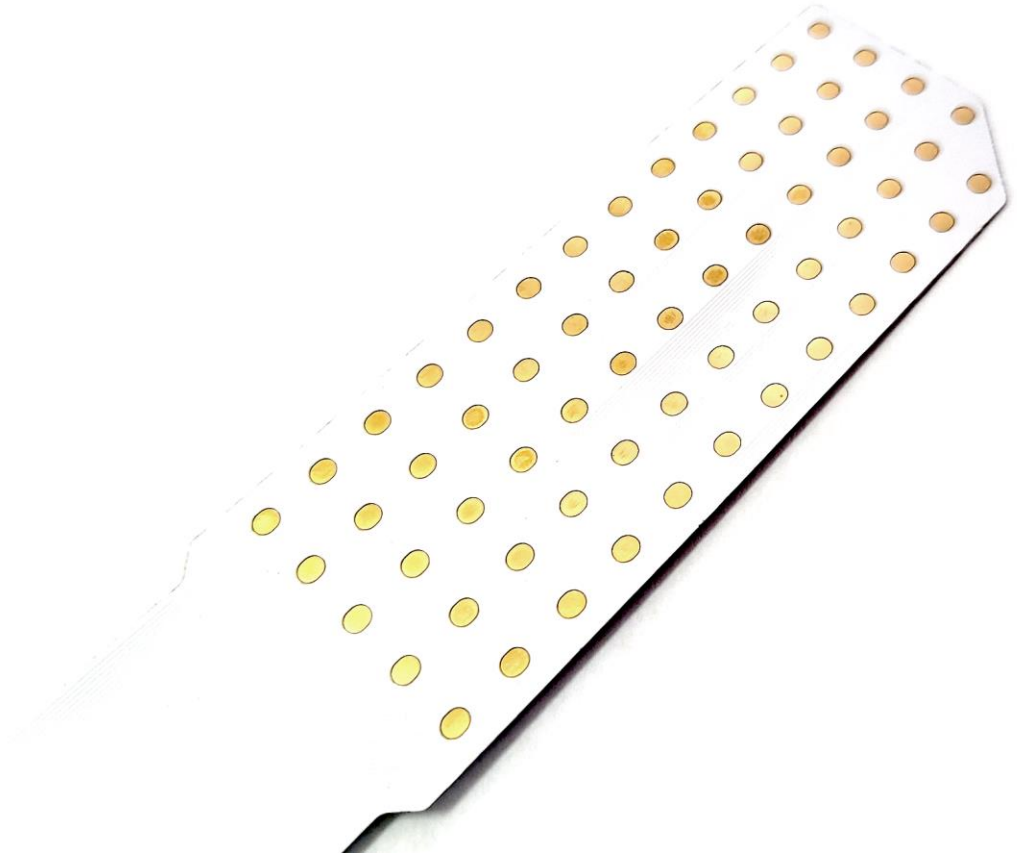

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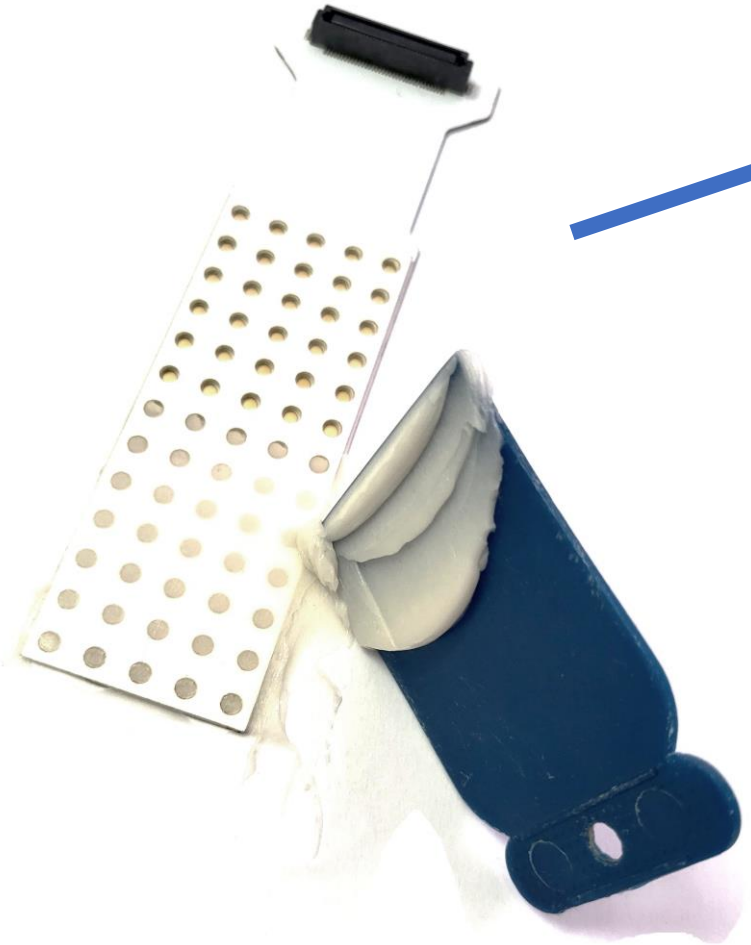
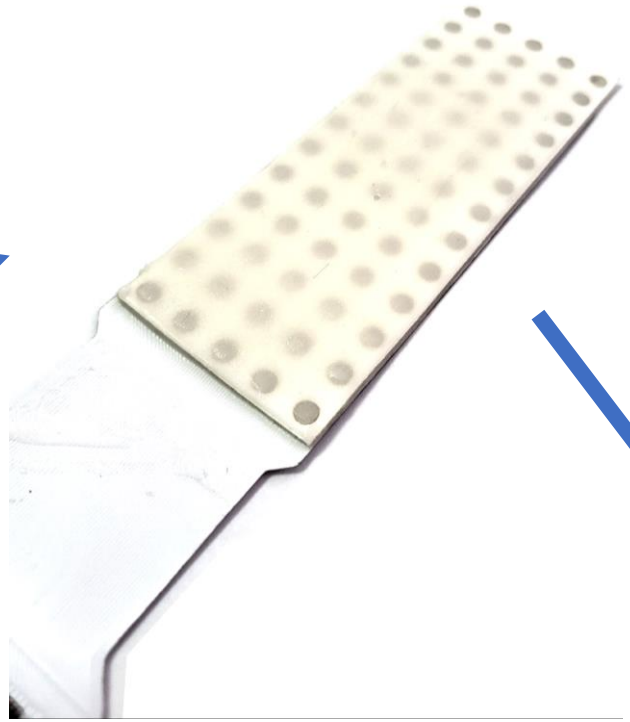
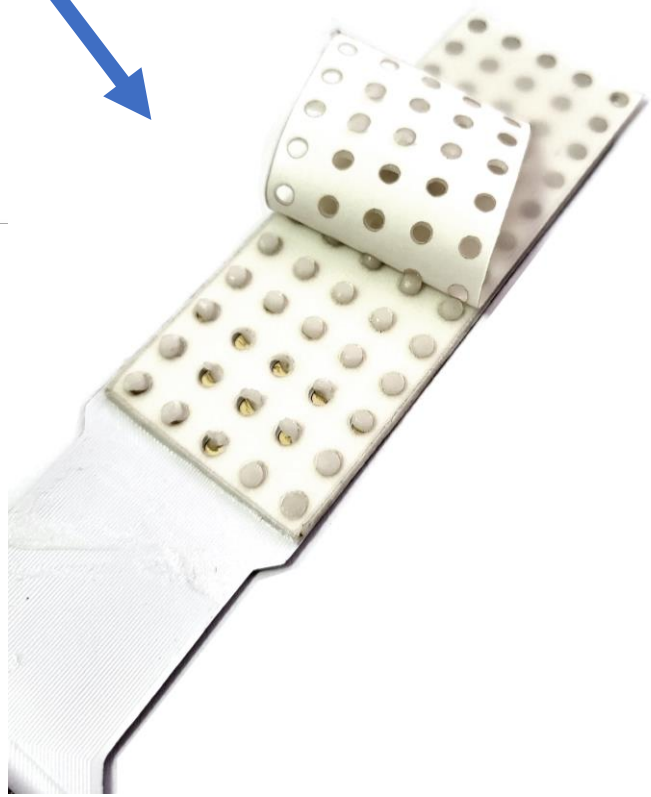
Electrode preparation







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Electrode preparation

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After placing the electrode to the skin

- Firmly fix (stick) the electrode to the skin
  - Fixation should, in the meaning of applied pressure, be as uniform as possible over the whole electrode
  - Try to avoid using medical tape (3M Micropore Tape) - on larger muscles
    - Taping the electrode can cause electrode bending
  - If possible, use wide elastic bands

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After placing the electrode to the skin

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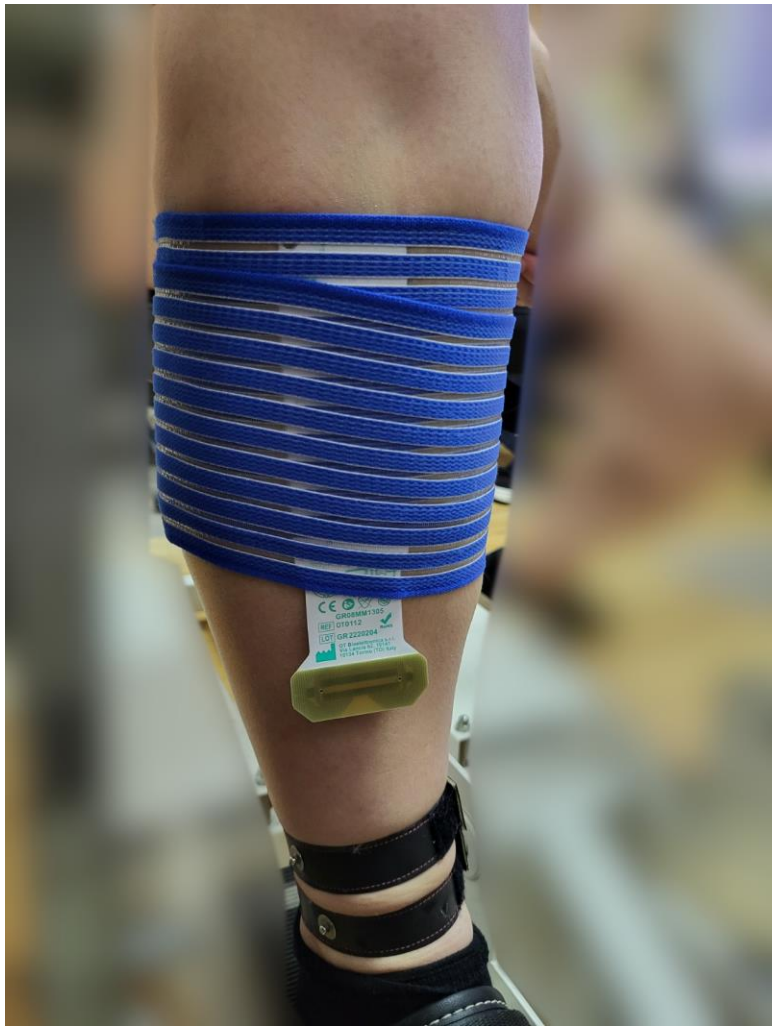

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References

- Attach to muscle inactive area
- Use textile reference strips if possible
  - Works better in case of dry skin
  - If using an adhesive reference electrode, add a bit of conductive paste/gel to the electrode
  - Don’t use small ECG electrodes for reference

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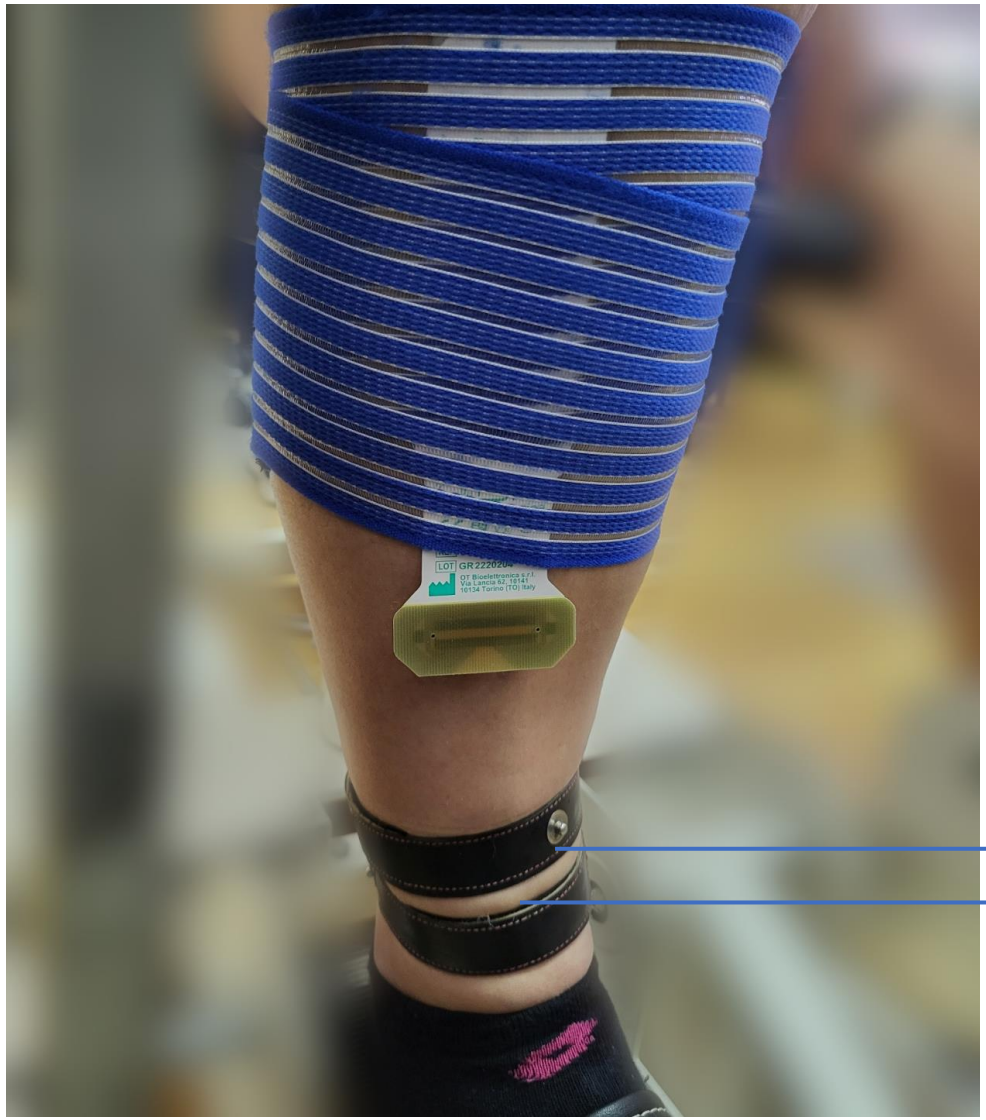
References



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Is everything okay?

- We did everything right, but we have noisy signals (or no signals – "*flat*")

- Let's take a look at some edge cases and try to identify the source of the problem

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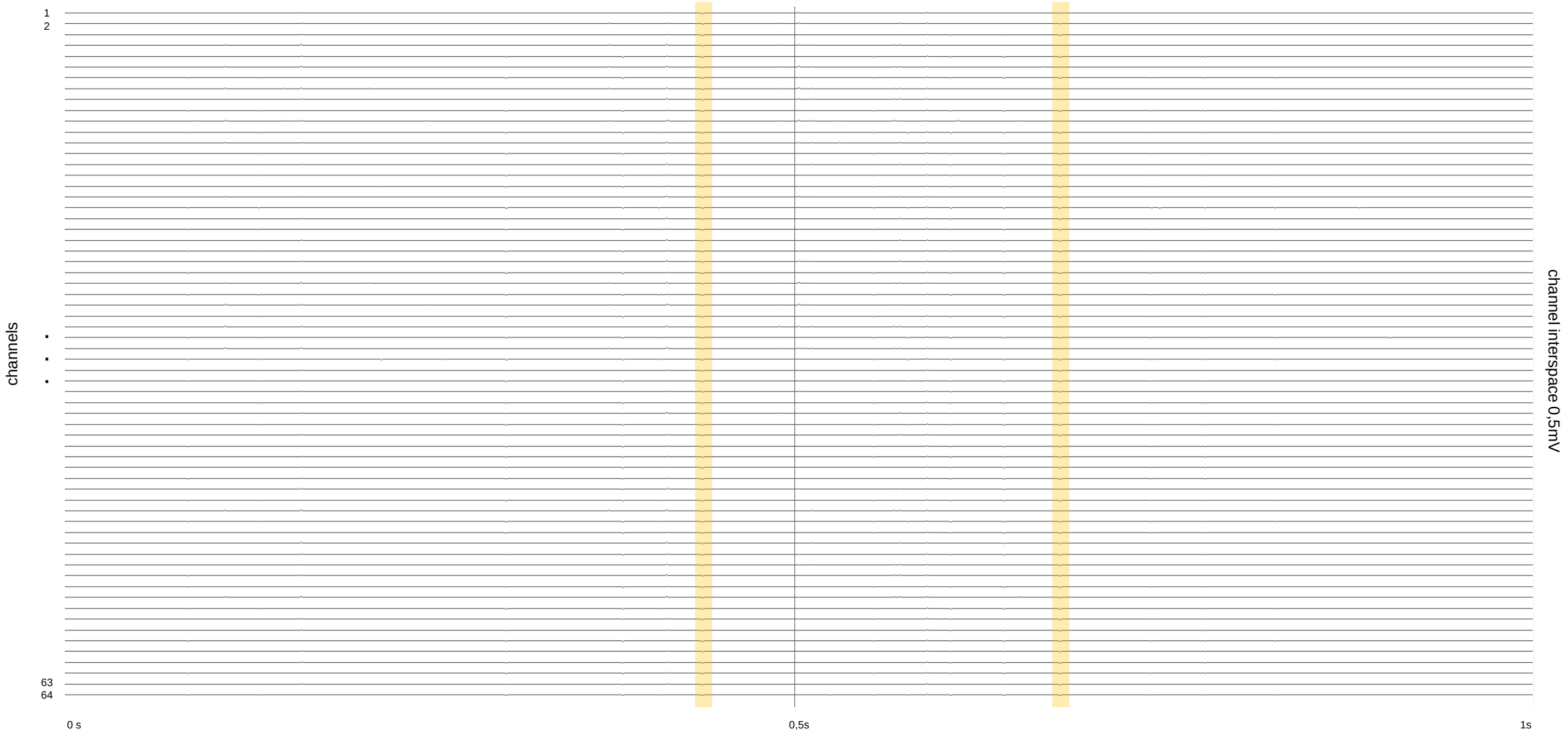
How can we identify the source of noise?



Insufficient cleansing of the skin (hard to tell apart from poorly prepared electrode)

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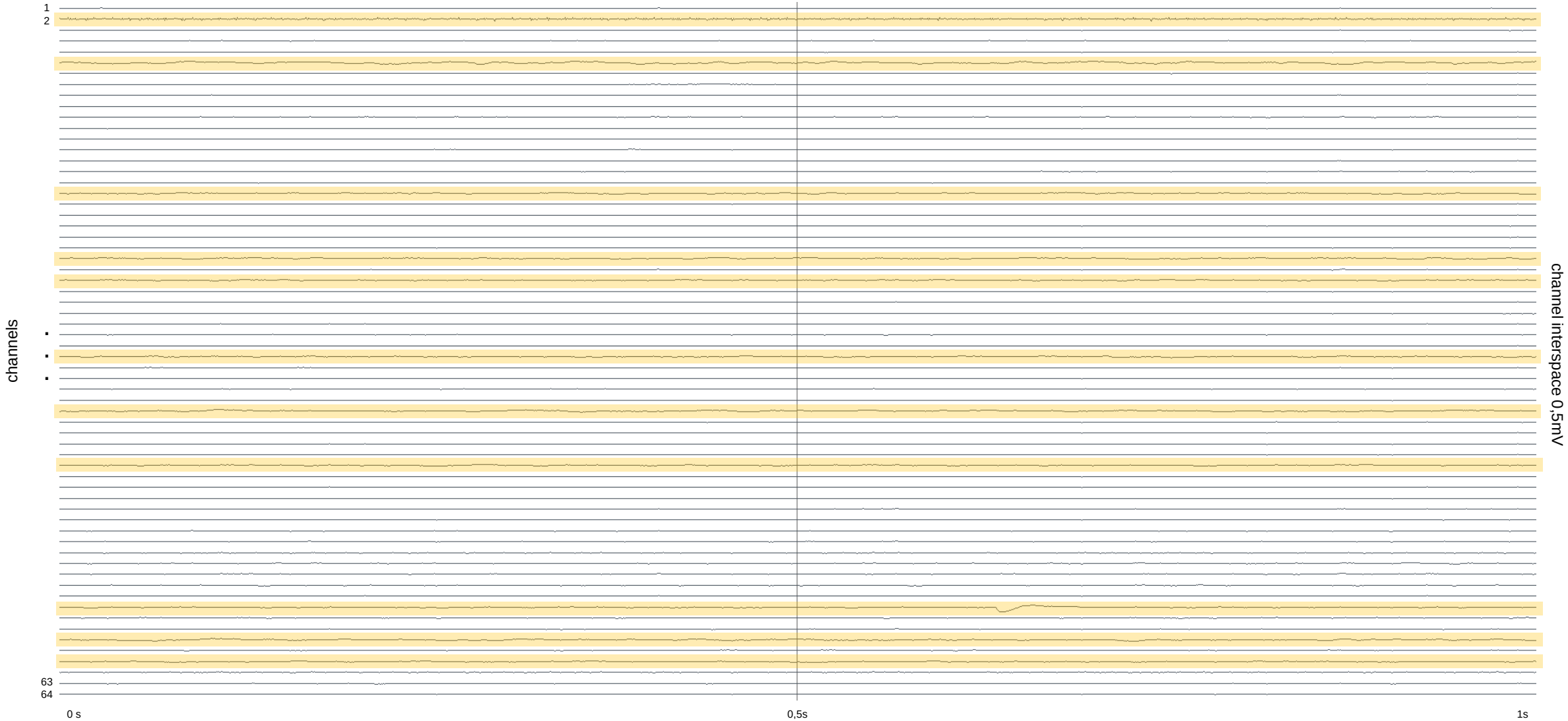
How can we identify the source of noise?



Poorly prepared electrode

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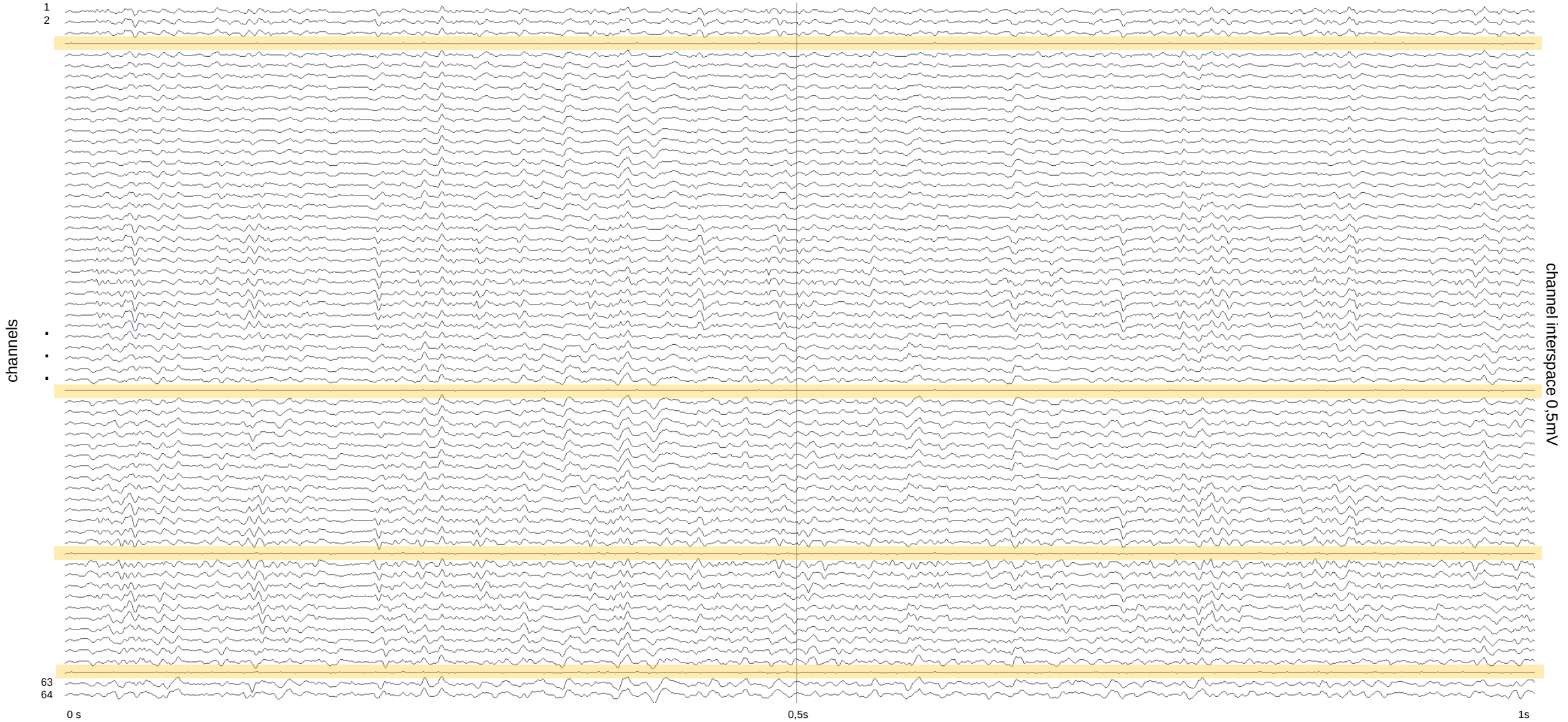

Poorly prepared electrode

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How can we identify the source of noise?

Bad (loosen) reference

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How can we identify the source of noise?

Pat Ref and Pre-Amp Ref are in contact

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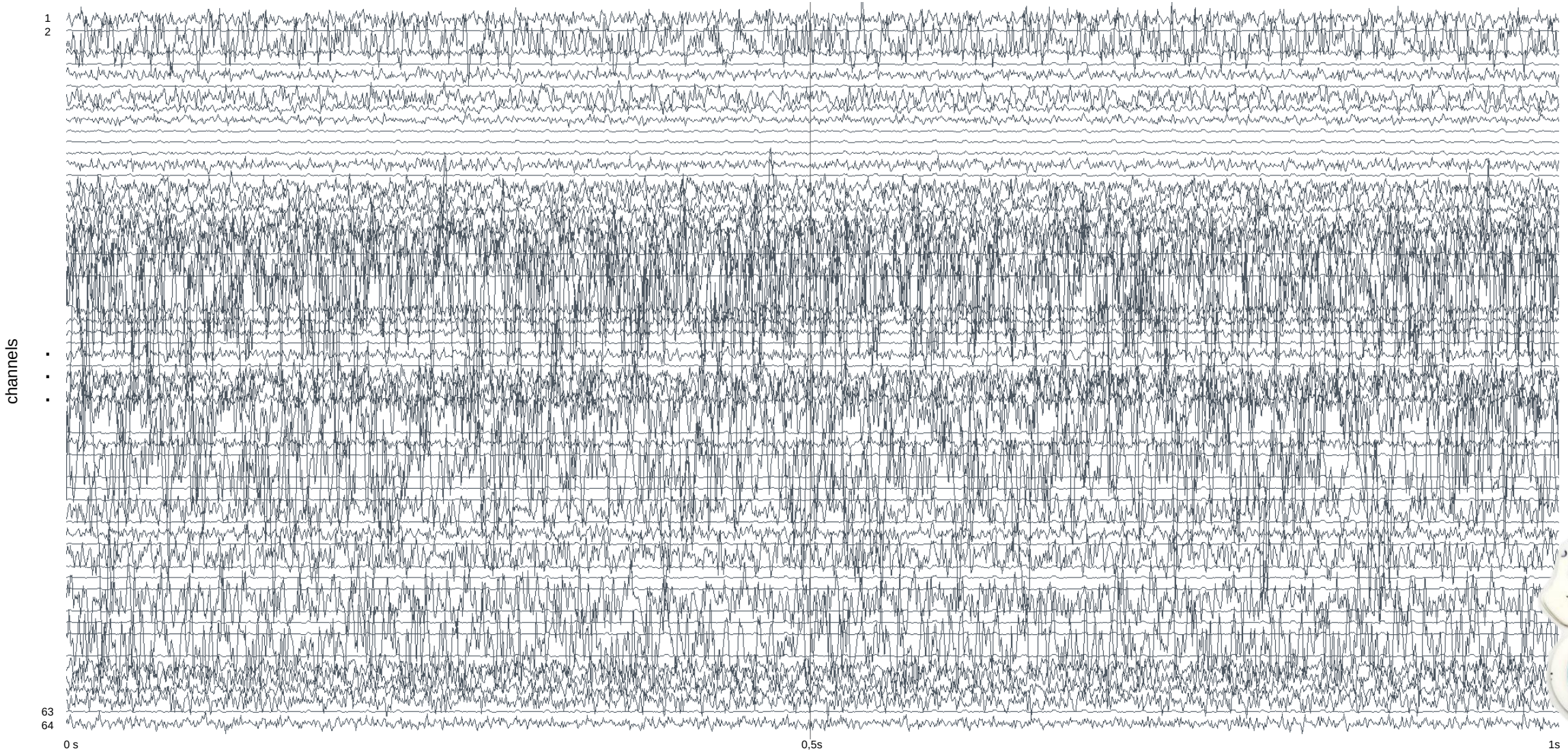
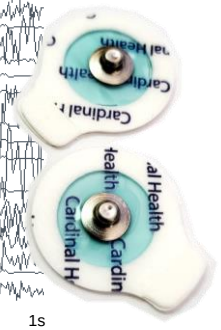
How can we identify the source of noise?





Improper reference electrode used

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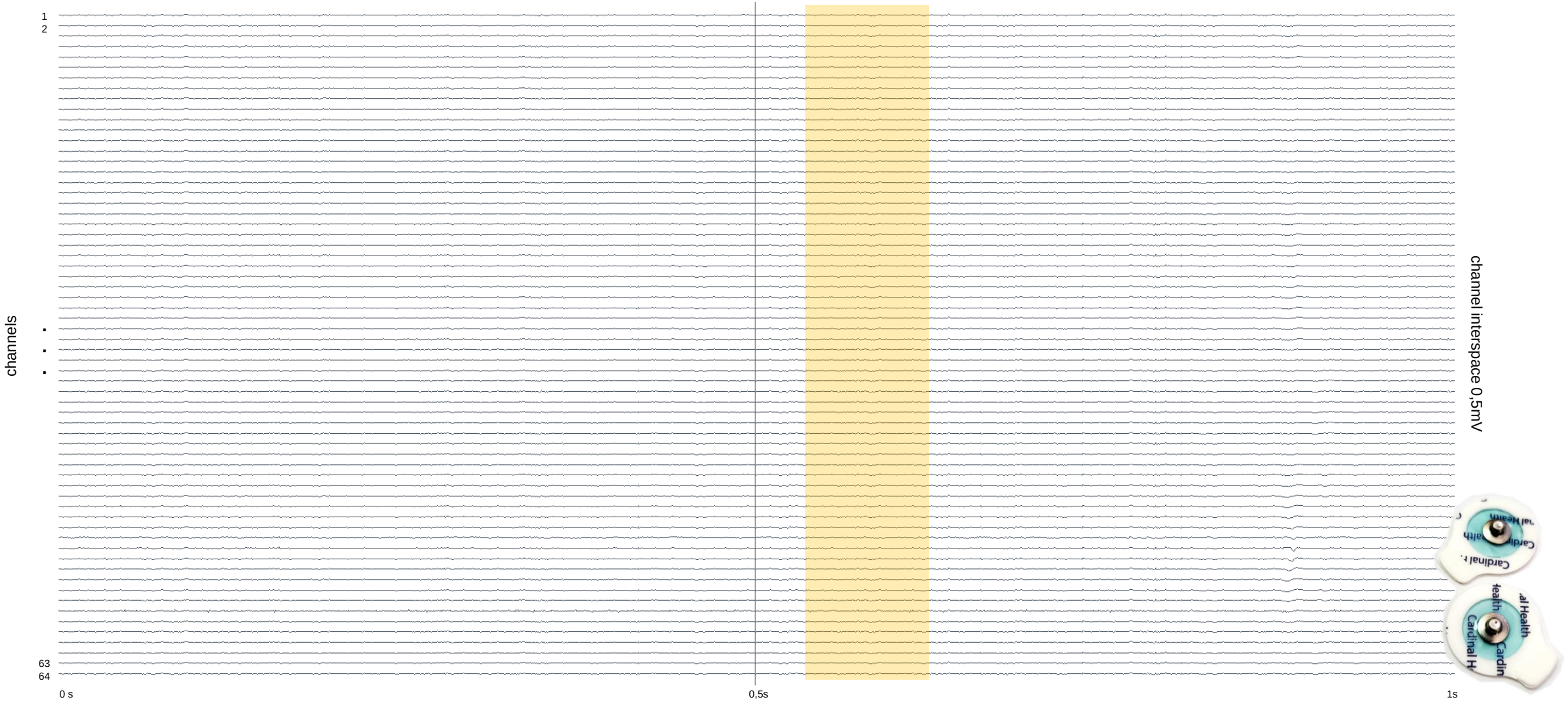
How can we identify the source of noise?



Improper reference electrode used (cleaned the skin underneath the el.)

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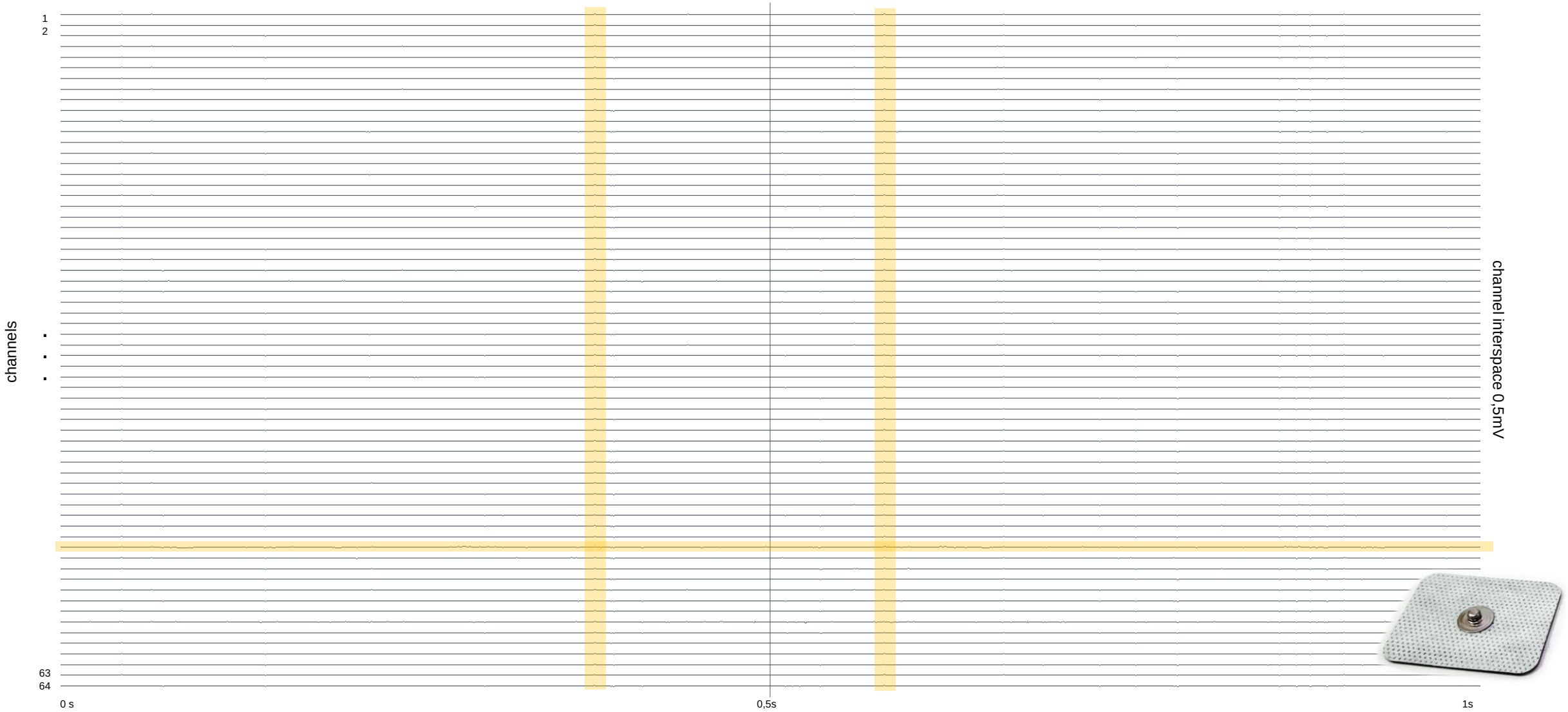
How can we identify the source of noise?



Improper reference electrode used (changed the electrode)

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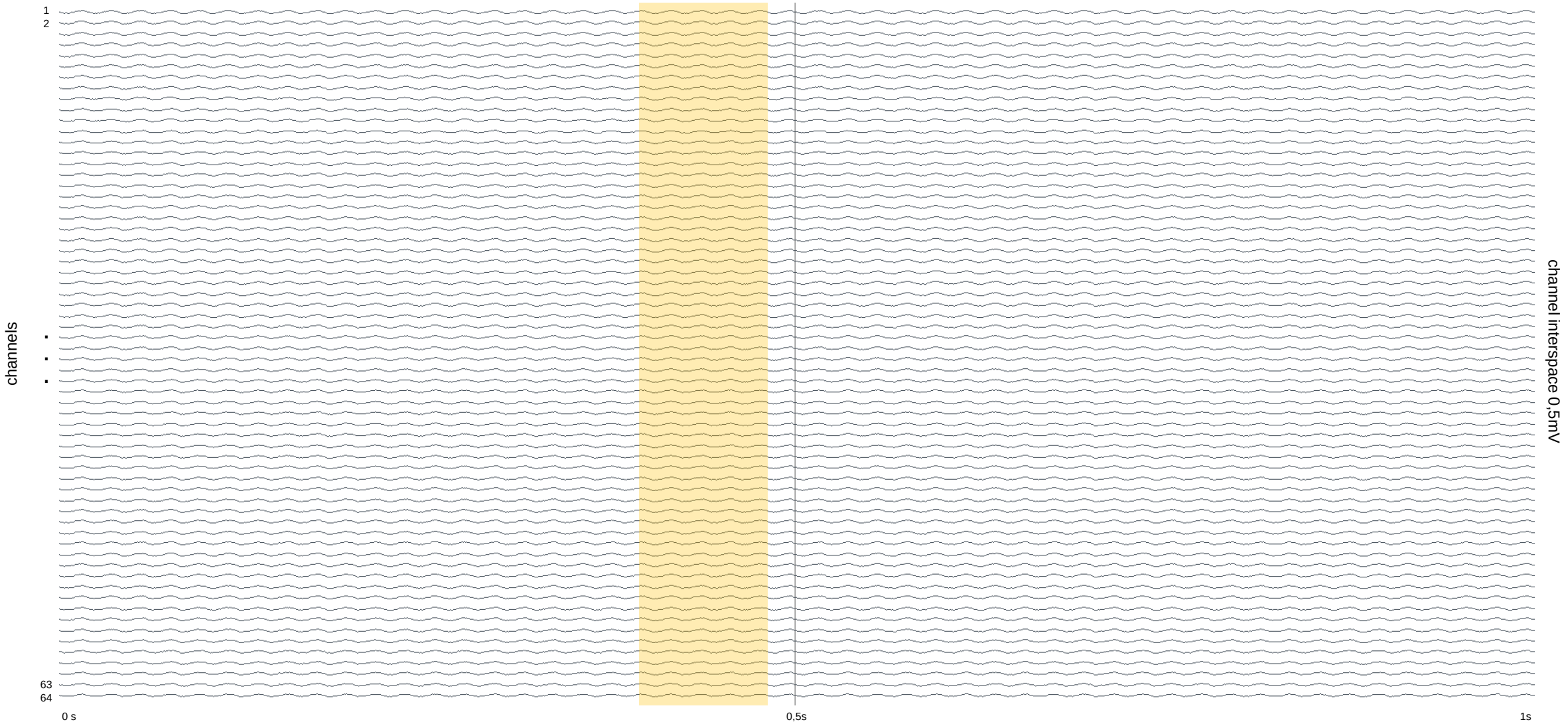
How can we identify the source of noise?



Line interference

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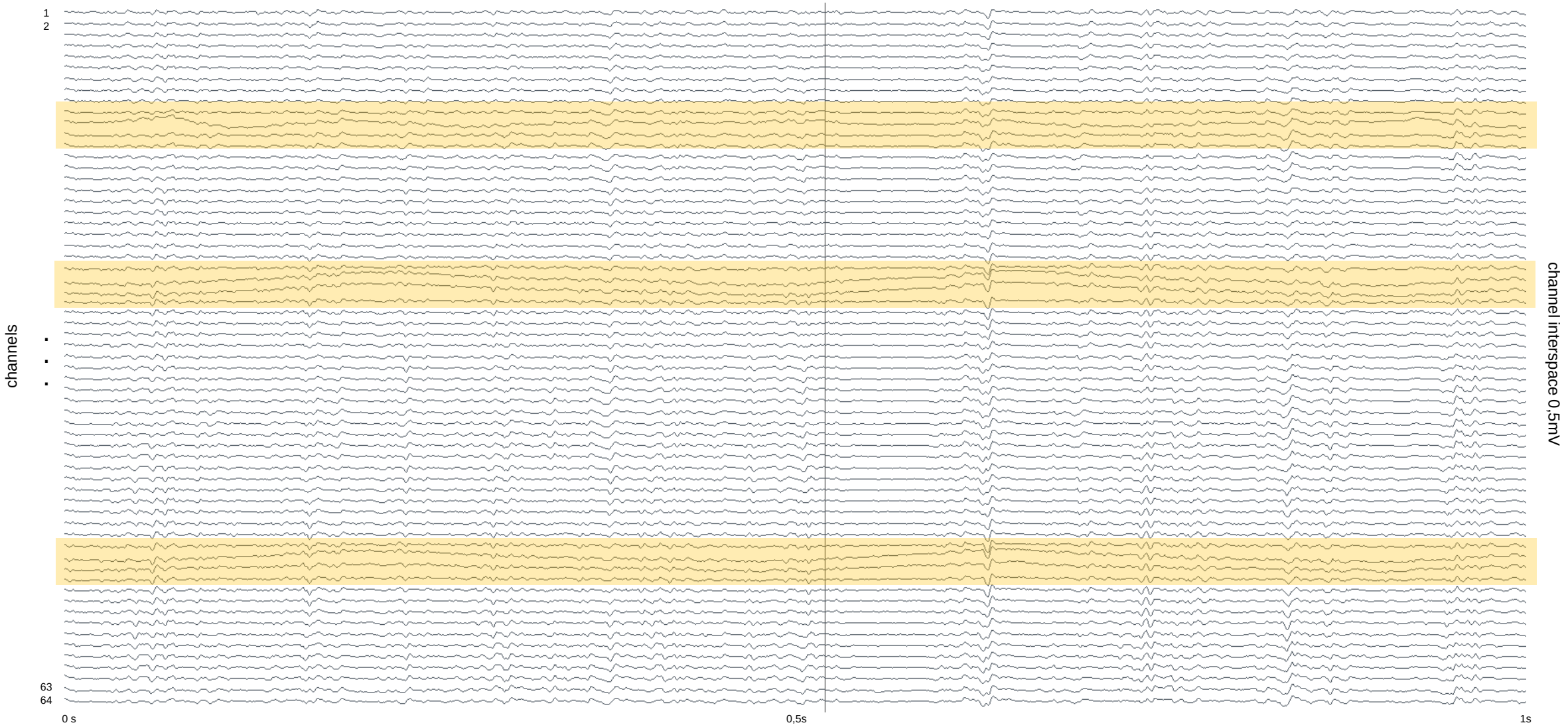
How can we identify the source of noise?



Movement artefact

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How can we identify the source of noise?

Participant can’t relax (can be mistaken for noise)

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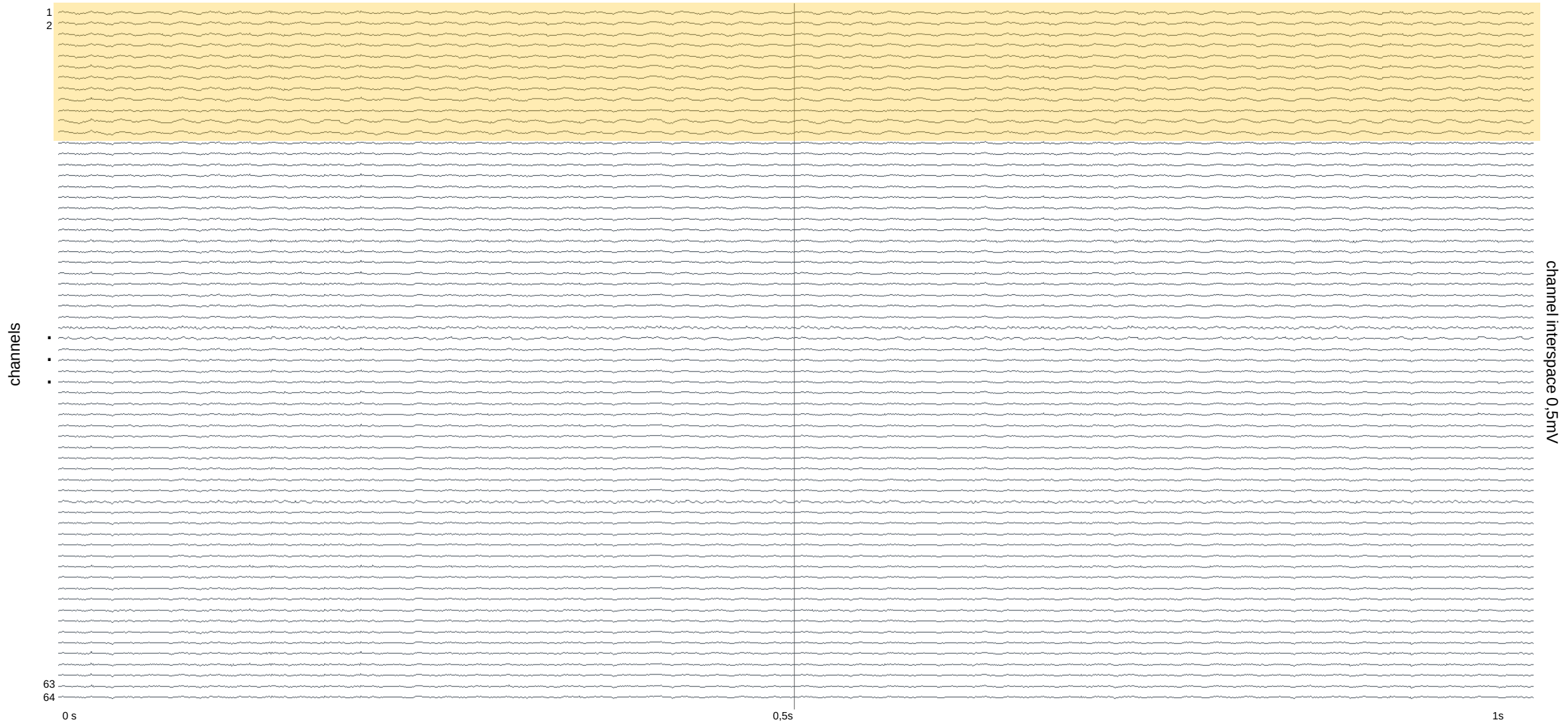
How can we identify the source of noise?



What do we have here?

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How can we identify the source of noise?

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How can we identify the source of noise?

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Some other possible “noises”:

- ECG
  - Reference on the opposite limb

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How to eliminate the noise (at least try to)?

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Electrode:

- Try warming up the electrode from the back side - *How?*
  - The paste will heat up and provide better conductance
- Remove the electrode, do additional skin cleaning and reapply the electrode
  - Can use the same electrode if the conductive paste stays in the holes
- Check if the electrode is strongly bent
  - Too strong taping
  - Can happen because of muscle activity - very prominent muscle

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How to eliminate the noise (at least try to)?

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Reference:

- Check if references have good contact with skin
  - Can be a problem with strip references and skinny participants
    - Prominent ankle bones, prominent ankle tendons, …
- Check if references are in contact
  - Can be a problem with smaller people
- Check if any reference is on the muscle-active area

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How to eliminate the noise (at least try to)?

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Other devices:

- Check if removing, for example, an electrical stimulator electrode from the participant makes any difference
  - Usually, we can't solve this
- Isolate other devices used in measurement
  - Place them on rubber mat, …
  - AUX connected devices can cause noise

Environment:

- Check if a participant is in contact with metal
- Check if a participant wears a smartwatch or has a mobile phone in his pocket
  - Vibration on new message received, …

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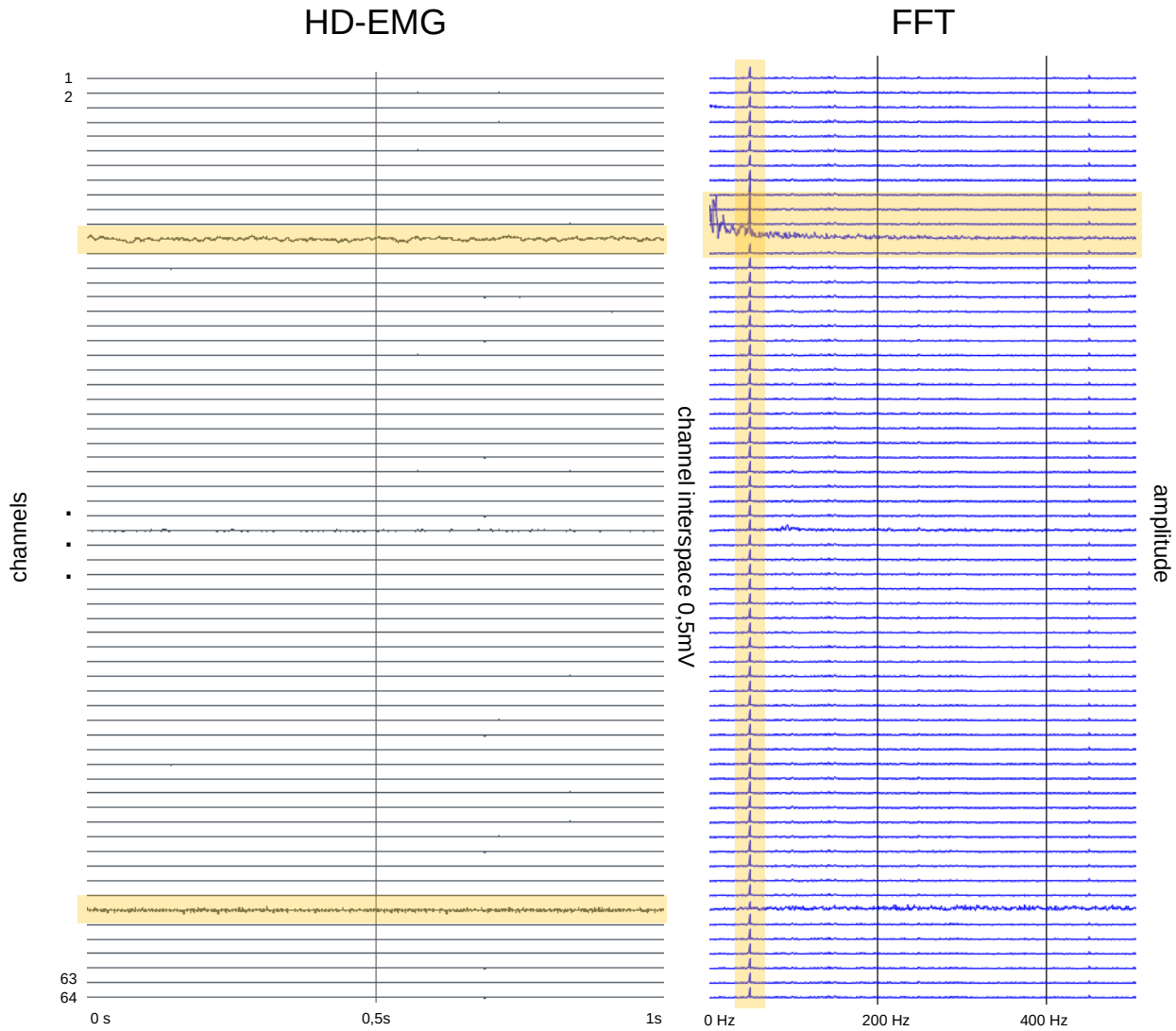
How to eliminate the noise (at least try to)?

What else to try:

- Quick frequency analysis



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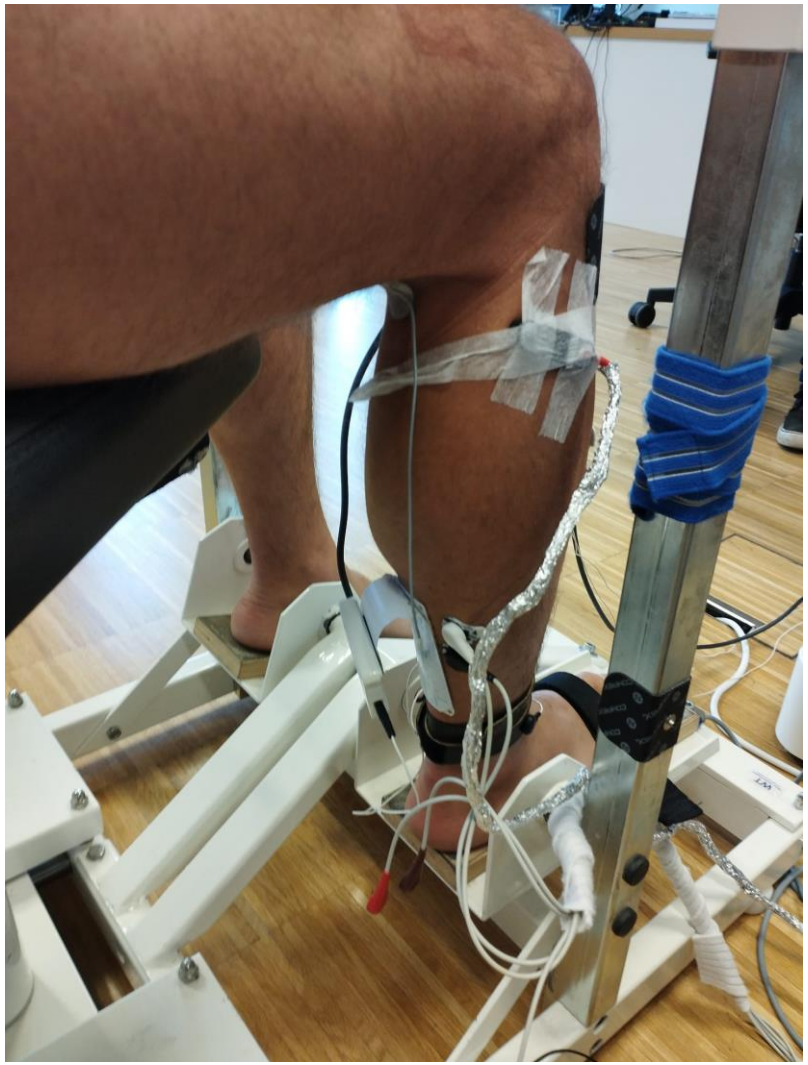
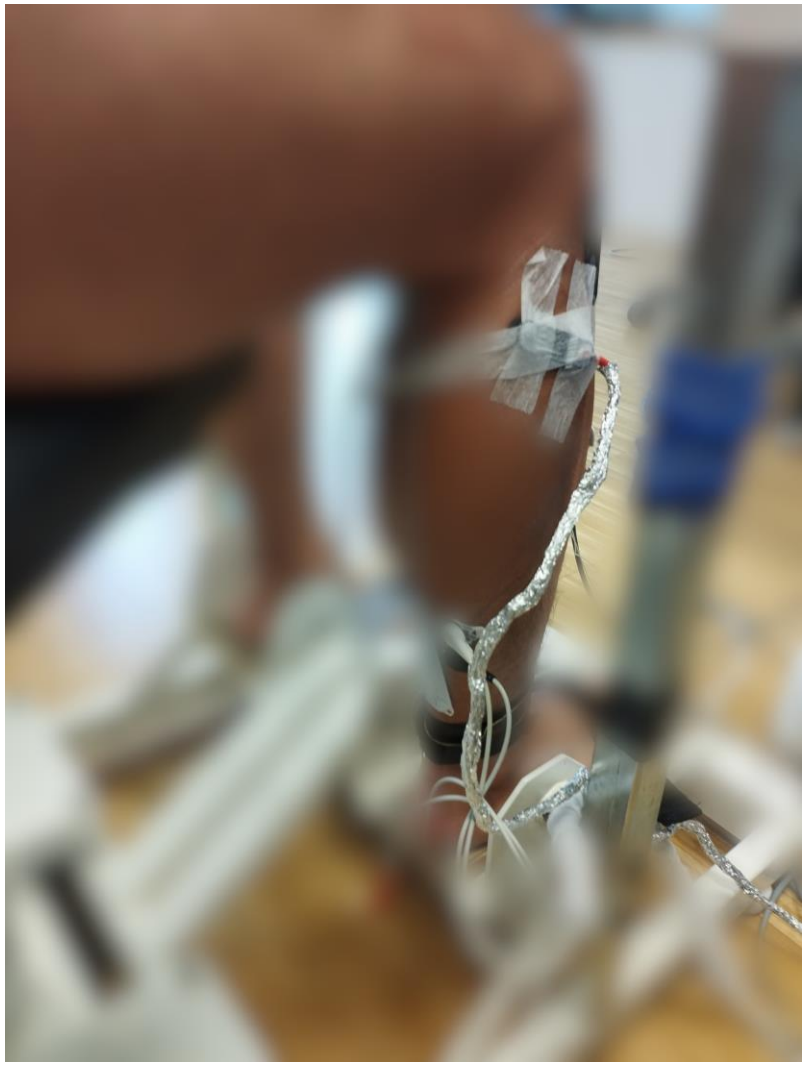
How to eliminate the noise (at least try to)?





One of our attempts to resolve noise coming from stim.

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How to eliminate the noise (at least try to)?

The most common steps when “unexplained” noise is present:

1) Light touch to the electrode should produce noise (usually 50 Hz)
   - A quick check if the system even works
2) Check if all references are OK
3) Try warming up the electrode
4) Try warming the electrode a bit more
5) Remove the electrode and do additional skin cleaning
6) Reattach the electrode and repeat step 3
7) Replace the electrode (or clean and re-paste) and repeat step 3

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When none of the attempts worked

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1) Stay calm!
2) Take a deep breath!
3) Blame a co-worker for poor electrode preparation
4) Convince a co-worker it's not your fault
5) Remember today's presentation and our *"scientifically"* proven theory:

   "Unalignment of Jupiter's moons can significantly affect surface EMG acquisition."

6) Pray to the EMG acquisition gods
7) Tell your boss you did everything in your power (you even waited for Jupiter's moons to realign) and that the problem is in the equipment used and he must buy you a new amplifier if he wants better signal quality

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When none of the attempts worked

- After the last step, signals will miraculously become *“perfect”*

OR (a more likely outcome)

- The boss will force you to repeat all the steps explained on the previous slides

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What to do with electrode after use?

- Clean the electrode
  - Use isopropyl alcohol - it dissolves Vaseline
  - Rinse with water
- Dry the electrode and save it for later use
  - Be sure to check the electrode for oxidation before reuse
  - Discolouring on individual electrodes

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Thank you!

Questions?

I will do additional practical demos during the poster session for those interested

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