Electrophysiology measures in perception and recognition

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WHAT DO WE TRULY...

See?

Remember?

Imagine?
THE TOOLS
NEURAL-BASED IMAGE RECONSTRUCTION

- Converting neural patterns into approximations of stimuli as perceived by an observer

image source: Radboud, AR databases

Nestor et al, 2016, PNAS
ELECTROENCEPHALOGRAPHY (EEG)

- The appeal of EEG: it is widely available, portable and much cheaper than fMRI
- The lack of appeal: poor spatial resolution
**Event Related Potentials (ERP)**

- A continuous EEG stream is divided into segments referenced to stimulus presentation and averaged across many trials.
SENSITIVITY TO VISUAL CATEGORIES

• ERP traces have different shapes in response to different visual categories (e.g., higher/lower amplitudes)

Rossion & Jacques, 2009
SENSITIVITY TO VISUAL EXEMPLARS

- ERP traces have different shapes even in response to different visual facial identities

Nemrodov et al, 2016
DATA COLLECTION & ANALYSIS

• Participants: 13 healthy young adults
• Two 2.5-hour sessions
• Stimuli: 54 male faces X 2 expressions

- EEG signals are signal-processed
- Machine learning techniques map neural patterns onto image patterns
EEG-BASED FACIAL IMAGE RECONSTRUCTION

• Converting EEG patterns into approximations of facial appearance as perceived by an observer

Nemrodov et al, 2018, eNeuro
FACE RECOGNITION & SKIN REFLECTANCE

- The appearance of an individual can change considerably due to facial hair, makeup/tanning, lighting, etc.

image source: FacePlace 3.0
The configuration of facial landmarks is less impacted by many such changes
AN EXAMPLE OF IMAGE RECONSTRUCTION OVER TIME

Nemrodov et al, in prep
AN EXAMPLE OF IMAGE RECONSTRUCTION OVER TIME

50-600ms
**Pros & Cons**

- Reconstruction is feasible and it recovers meaningful structure
- It worked with every single participant so far
- Only 2 testing sessions are needed per participant

- But accuracy and perceptual quality are quite low
- But they were all healthy young adults
- It involves several hours of testing, offline data processing
**CHALLENGES & ONGOING WORK**

- Memory vs perception-based reconstruction
- Better machine learning tools & integration with algorithms for automatic face recognition
- More diverse & realistic stimuli (e.g., faces in the wild)
EEG-based visual word reconstruction

- Converting EEG patterns into approximations of visual words read by an observer
SUMMARY

• EEG supports neural-based image reconstruction

• It paves the way to novel applications
  (e.g., reconstructing the facial appearance of a person of interest)

• It will be the target of methods/hardware optimization
Thank you!

Visual Recognition Lab / UTSC