

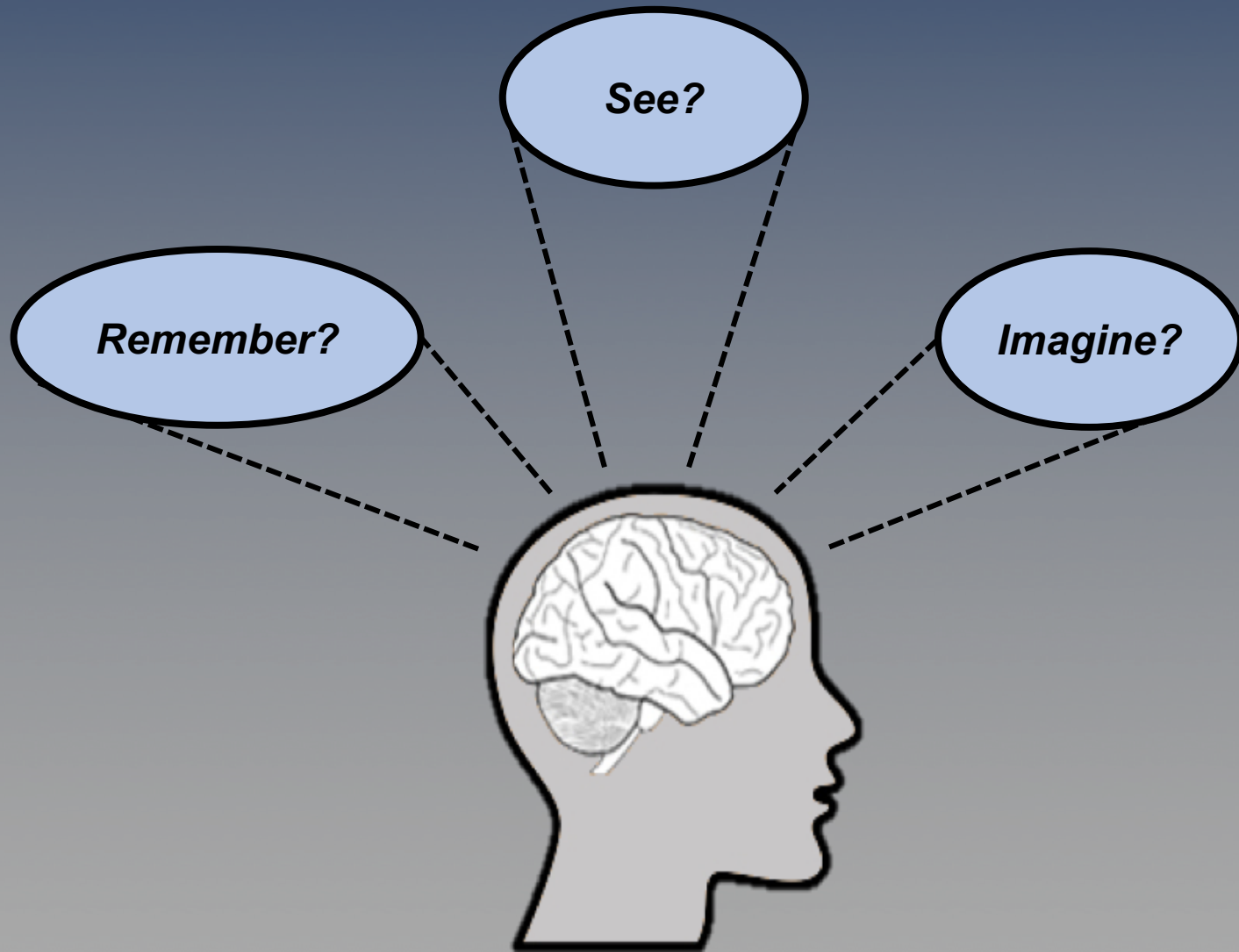
# ELECTROPHYSIOLOGY MEASURES IN PERCEPTION AND RECOGNITION

Adrian Nestor

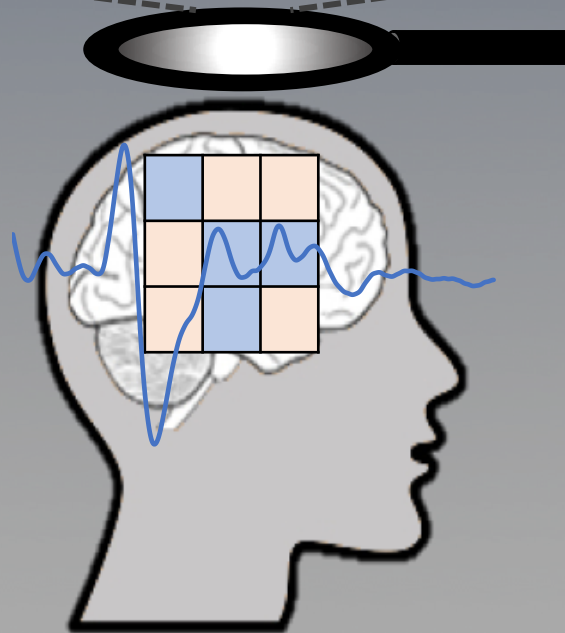
*University of Toronto*



# WHAT DO WE TRULY...

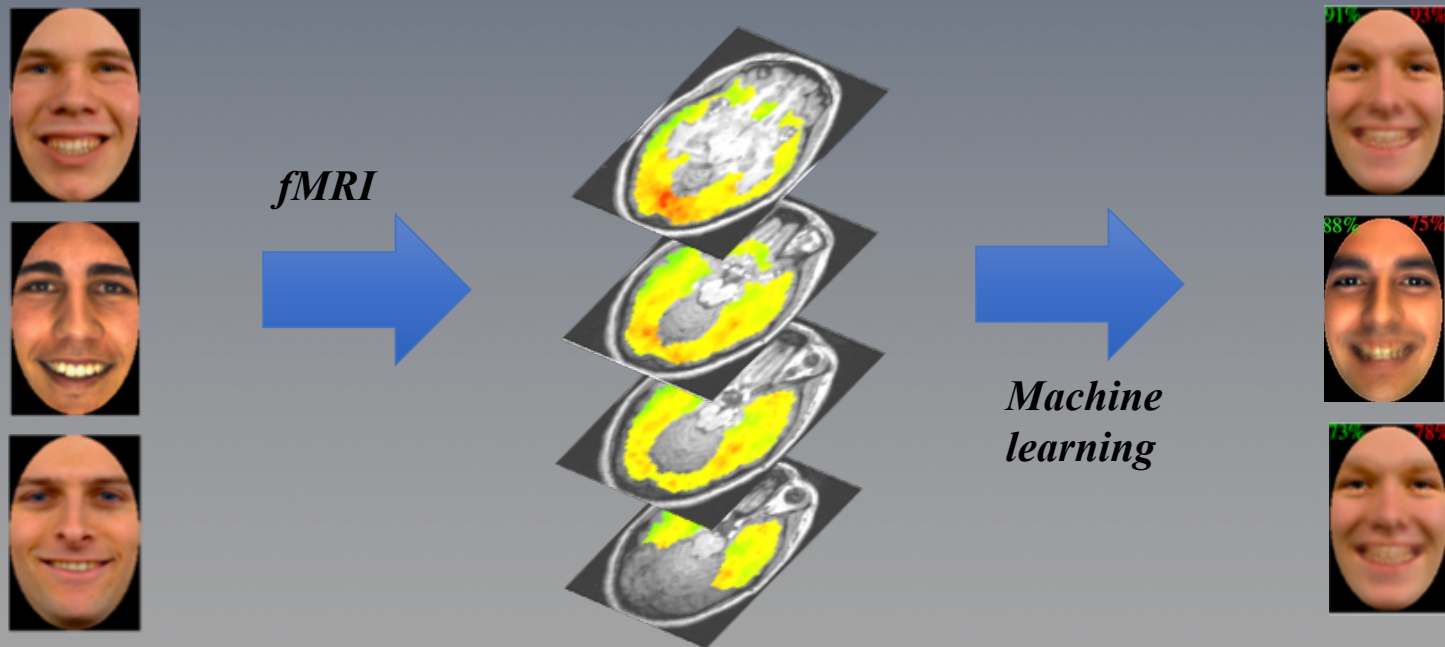


# THE TOOLS



# NEURAL-BASED IMAGE RECONSTRUCTION

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

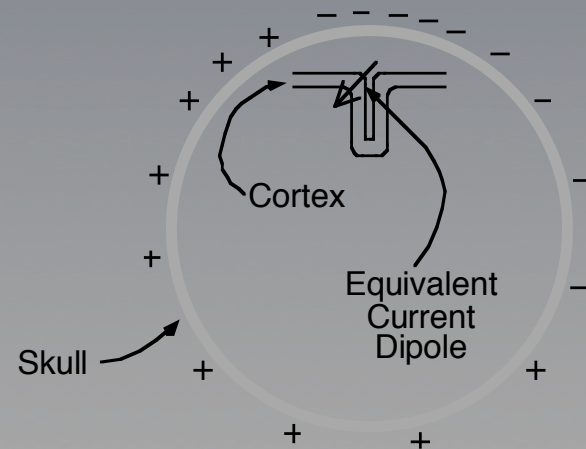
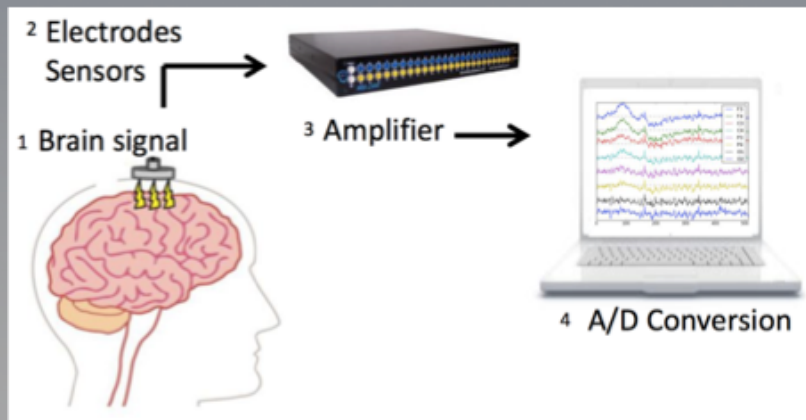


*image source:*  
*Radboud, AR databases*

*Nestor et al, 2016, PNAS*

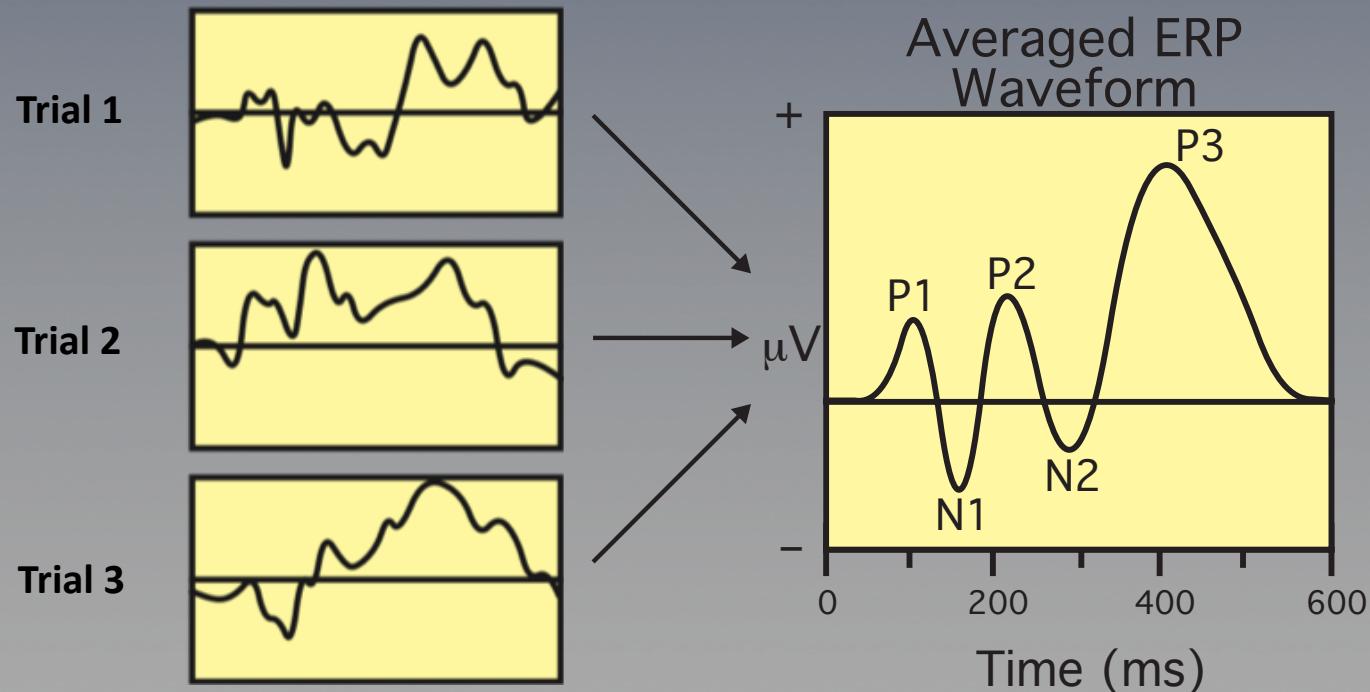
# ELECTROENCEPHALOGRAPHY (EEG)

- The appeal of EEG: it is widely available, portable and much cheaper than fMRI
- The lack of appeal: poor spatial resolution



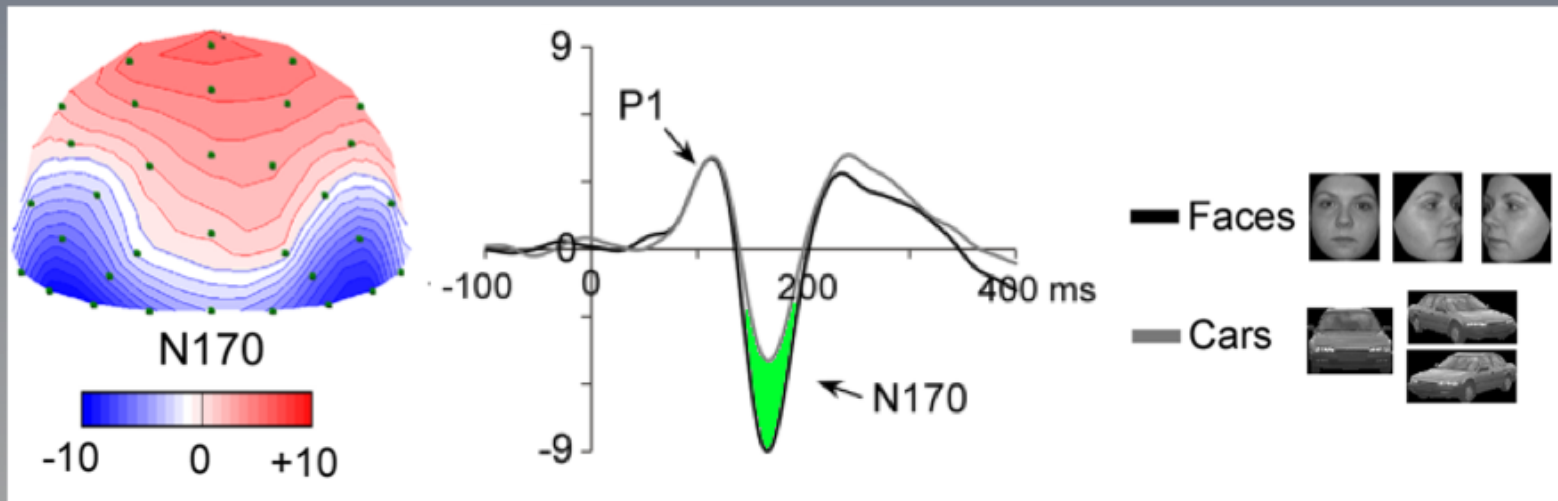
# EVENT RELATED POTENTIALS (ERP)

- A continuous EEG stream is divided into segments referenced to stimulus presentation and averaged across many trials



# SENSITIVITY TO VISUAL CATEGORIES

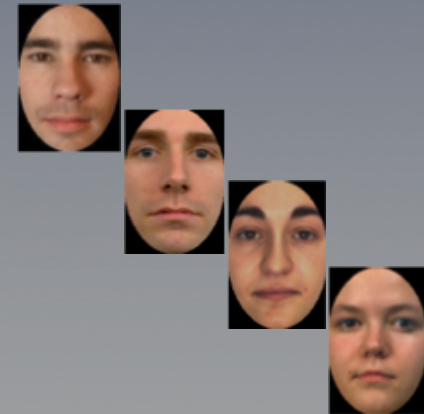
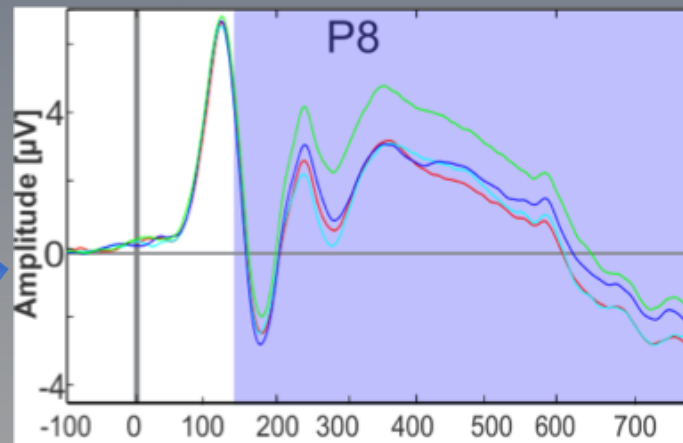
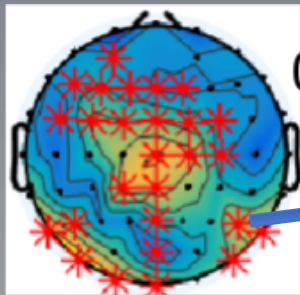
- ERP traces have different shapes in response to different visual categories (e.g., higher/lower amplitudes)





# SENSITIVITY TO VISUAL EXEMPLARS

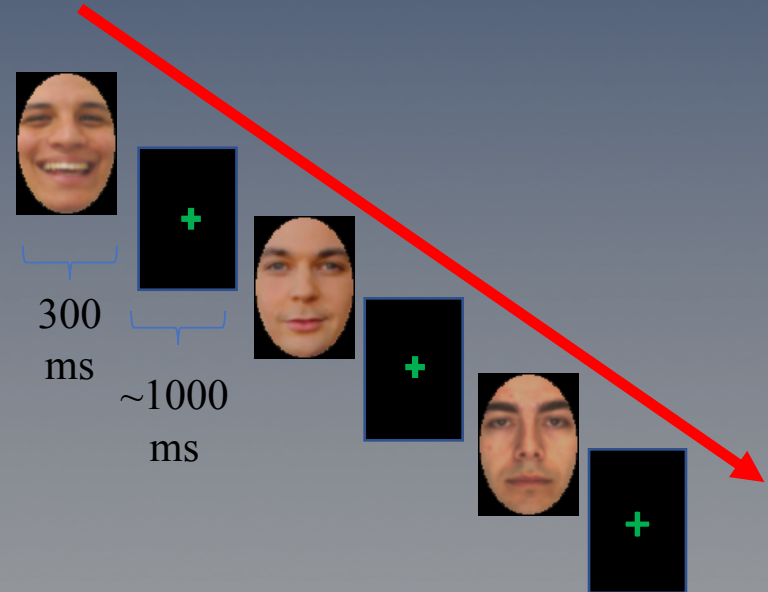
- ERP traces have different shapes even in response to different visual facial identities



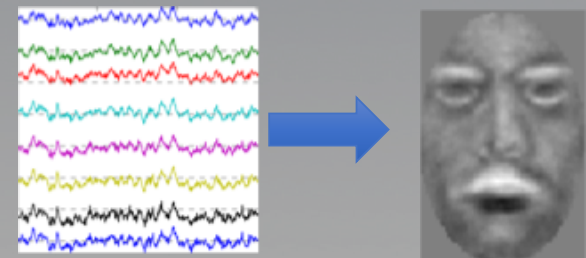


# DATA COLLECTION & ANALYSIS

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

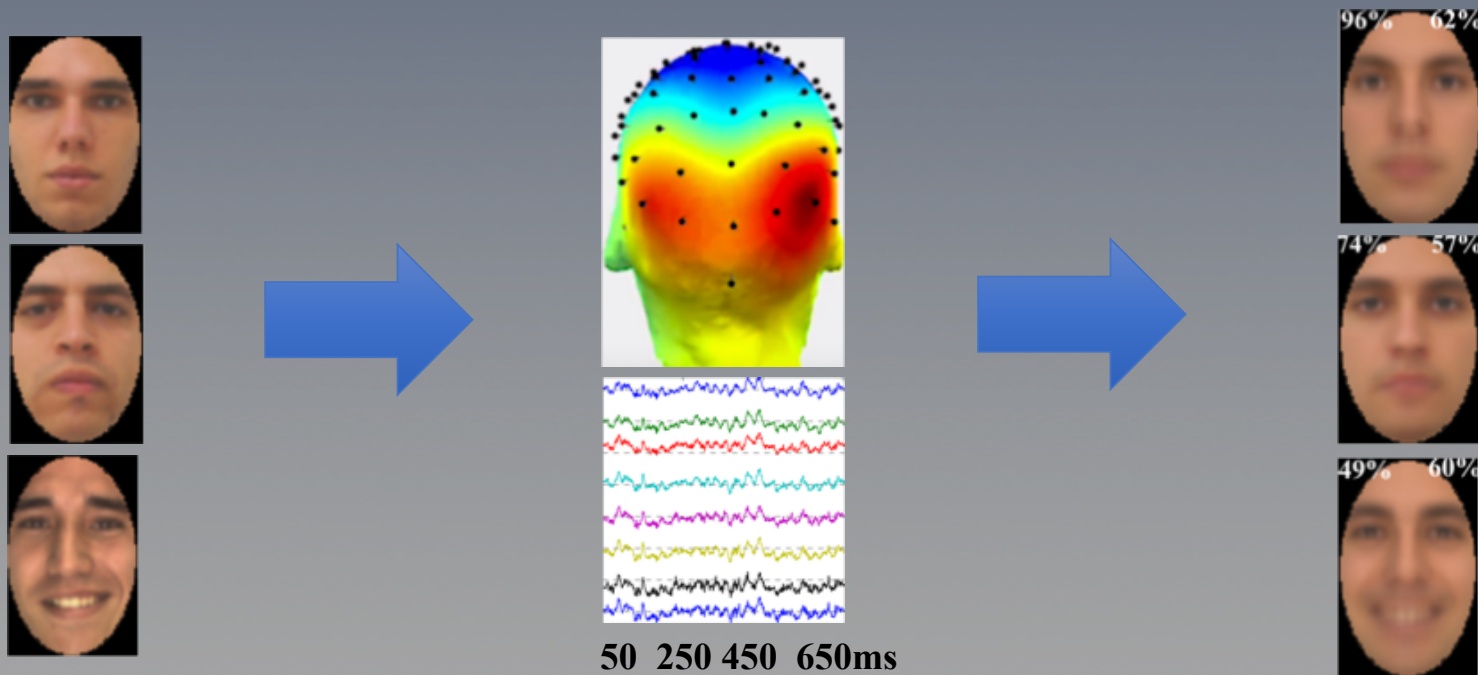


- EEG signals are signal-processed
- Machine learning techniques map neural patterns onto image patterns



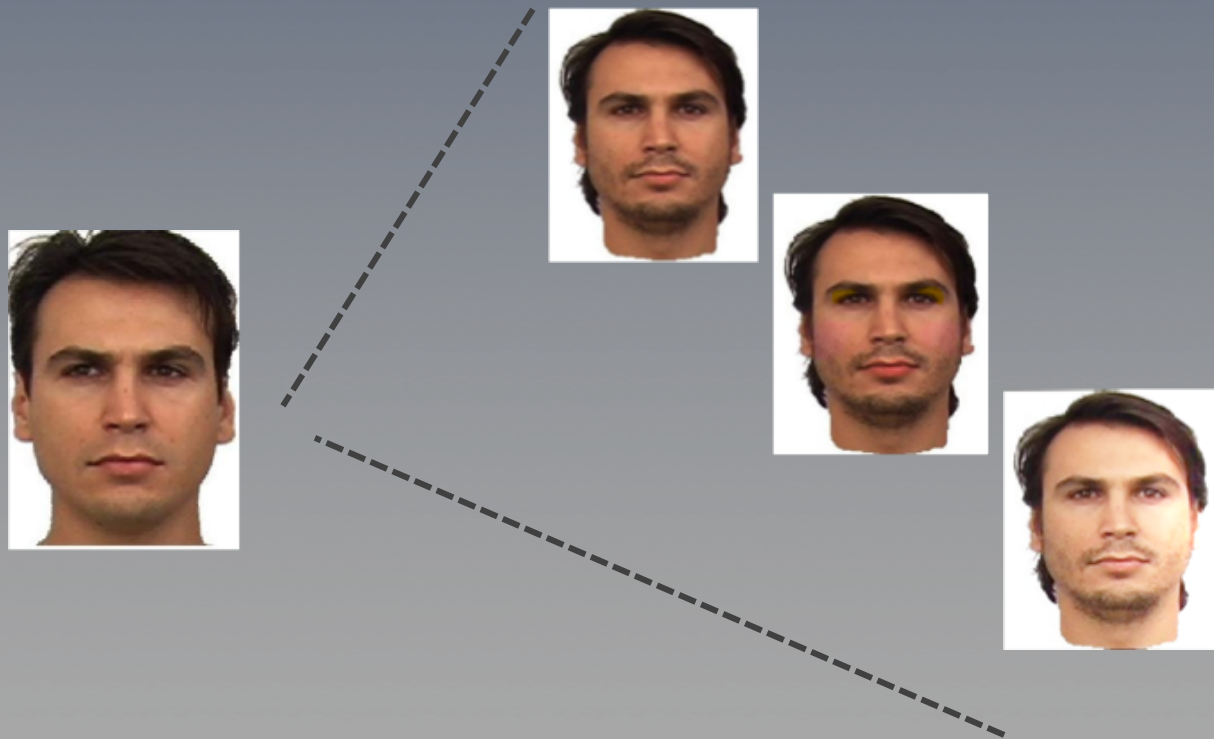
# EEG-BASED FACIAL IMAGE RECONSTRUCTION

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



# FACE RECOGNITION & SKIN REFLECTANCE

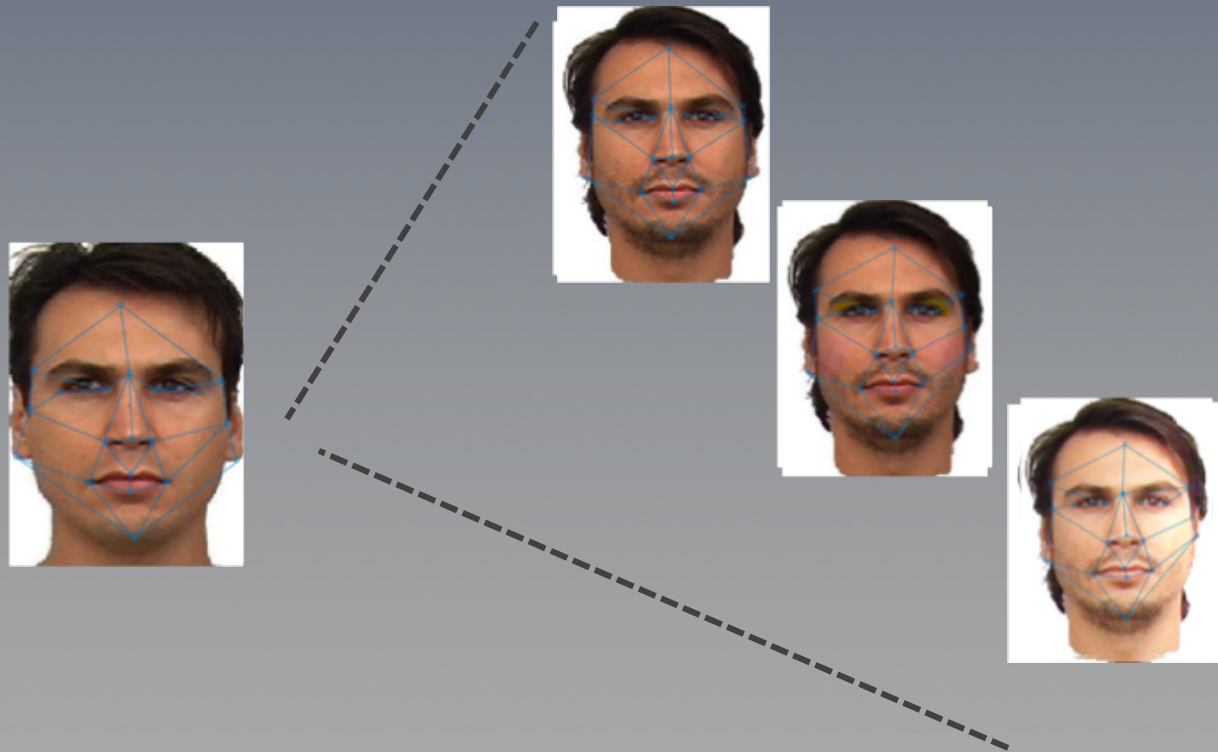
- The appearance of an individual can change considerably due to facial hair, makeup/tanning, lighting, etc.



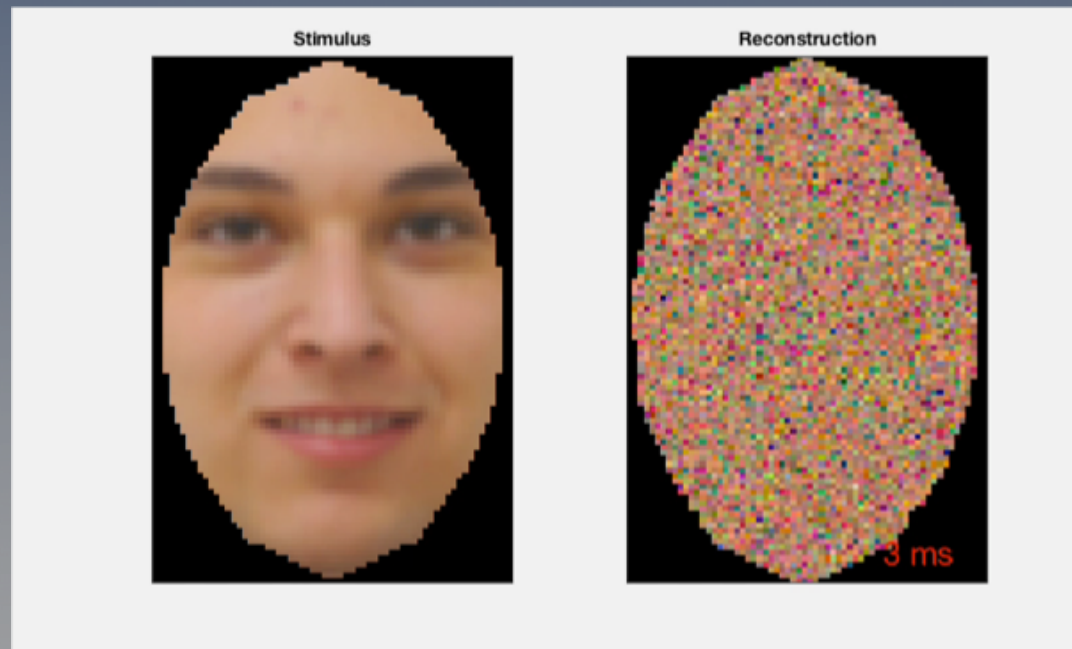
*image source:  
FacePlace 3.0*

# FACE RECOGNITION & FACIAL STRUCTURE

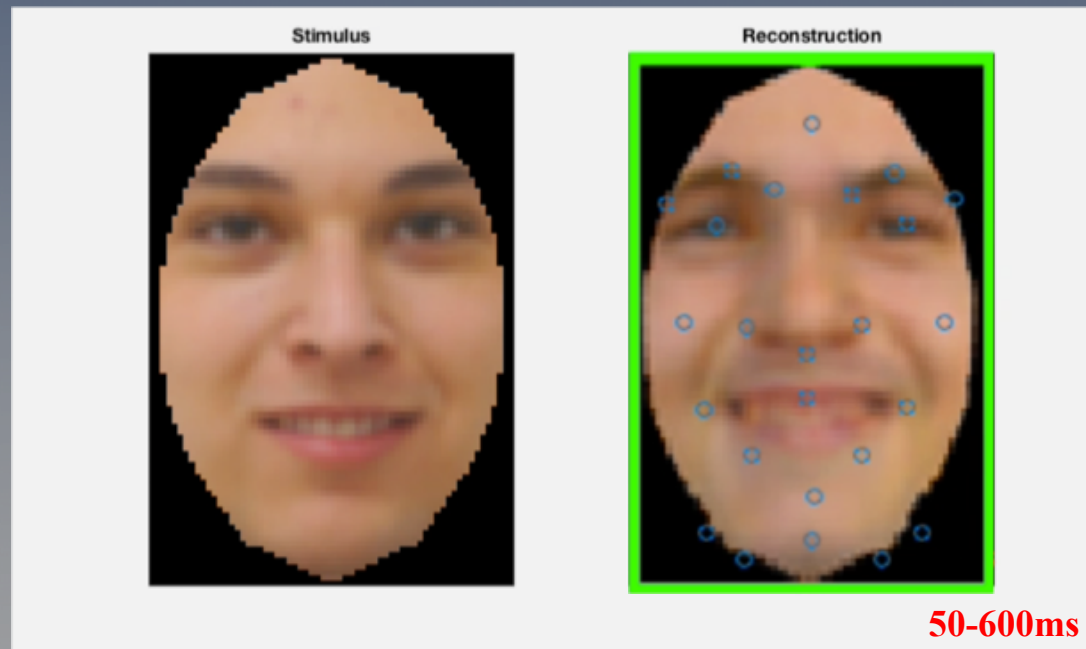
- The configuration of facial landmarks is less impacted by many such changes



# AN EXAMPLE OF IMAGE RECONSTRUCTION OVER TIME



# AN EXAMPLE OF IMAGE RECONSTRUCTION OVER TIME



# PROS & CONS

- Reconstruction is feasible and it recovers meaningful structure
- But accuracy and perceptual quality are quite low
- It worked with every single participant so far
- But they were all healthy young adults
- Only 2 testing sessions are needed per participant
- It involves several hours of testing, offline data processing



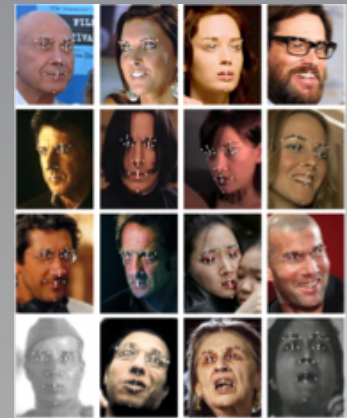
# CHALLENGES & ONGOING WORK

- 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)



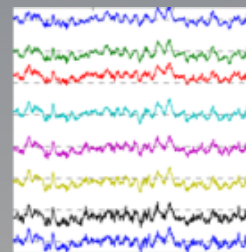
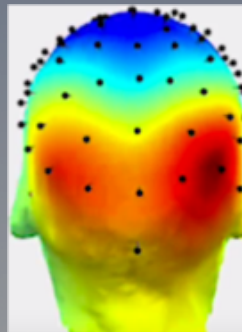
# EEG-BASED VISUAL WORD RECONSTRUCTION

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

hug

fig

gem



50 250 450 650ms



aug

fig

gem

# 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*

