Distinct but Effective Neural Networks for Facial Emotion Recognition in Individuals with Autism: A Deep Learning Approach

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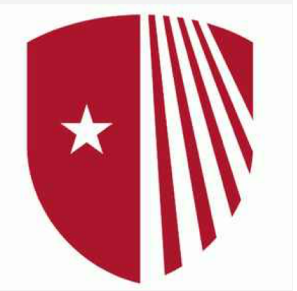
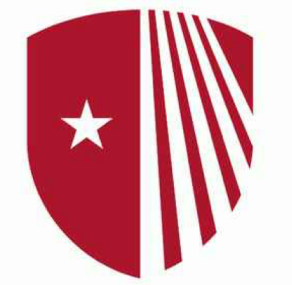


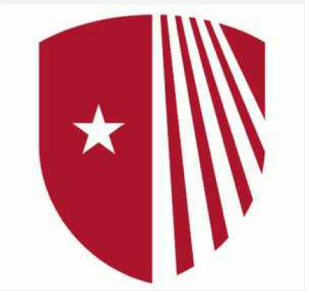
Background

1. Individuals with ASD evince deficits in facial emotion recognition (FER; Lozier et al., 2014)
2. Failure to *encode* FER information OR to deploy correctly-encoded information (Yang et al., 2018, Dawson et. al 2005)



Background

1. Deep Convolutional Neural Networks (Deep ConvNets)
    - Isolate neural networks for encoding FER using single-trial EEG
2. Deep ConvNets can determine if those with ASD correctly encode FER similarly to non-ASD individuals



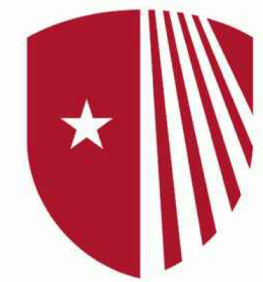
Outline

1. Experiment Design / Participant Samples
2. Deep ConvNet Architecture
    - Performances Results
3. iNNvestigate package
    - Saliency/Feature-importance Results
4. Conclusions

Questions and Hypothesis

1. Are face emotion recognition (FER) deficits in ASD exhibited at the level of neural encoding?
    - Can Deep Learning successfully decode emotion recognition from neural activity elicited by the viewing of faces?

1. What is distinct about the way individuals with ASD *are* encoding emotions, when and where do they do so?



Experiment Design - Participants Sample #1

	TD *N* = 48		ASD *N* = 40	
	μ or #	σ or %	μ or #	σ or %
Age (years)	16.73	3,41	14.89	2.35
Male N, %	29	60.42%	32	80.0%
ADOS-CSS	3.33	2.71	8.15	2.05
IQ	107.82	14.03	100.78	16.54

IQ is calculated averaging across participants per group

Questions and Hypothesis

Deep ConvNet

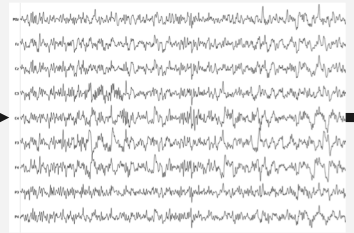
Blackbox?

DANVA-2 faces

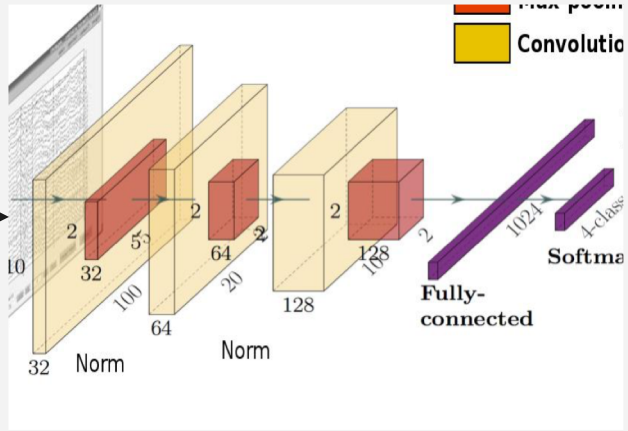
FER

TD/ASD participants

Elicitation



EEG neural activity



Questions and Hypothesis

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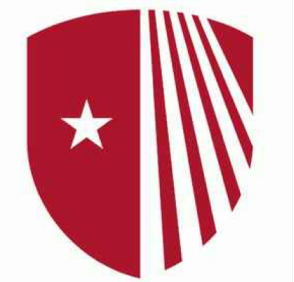
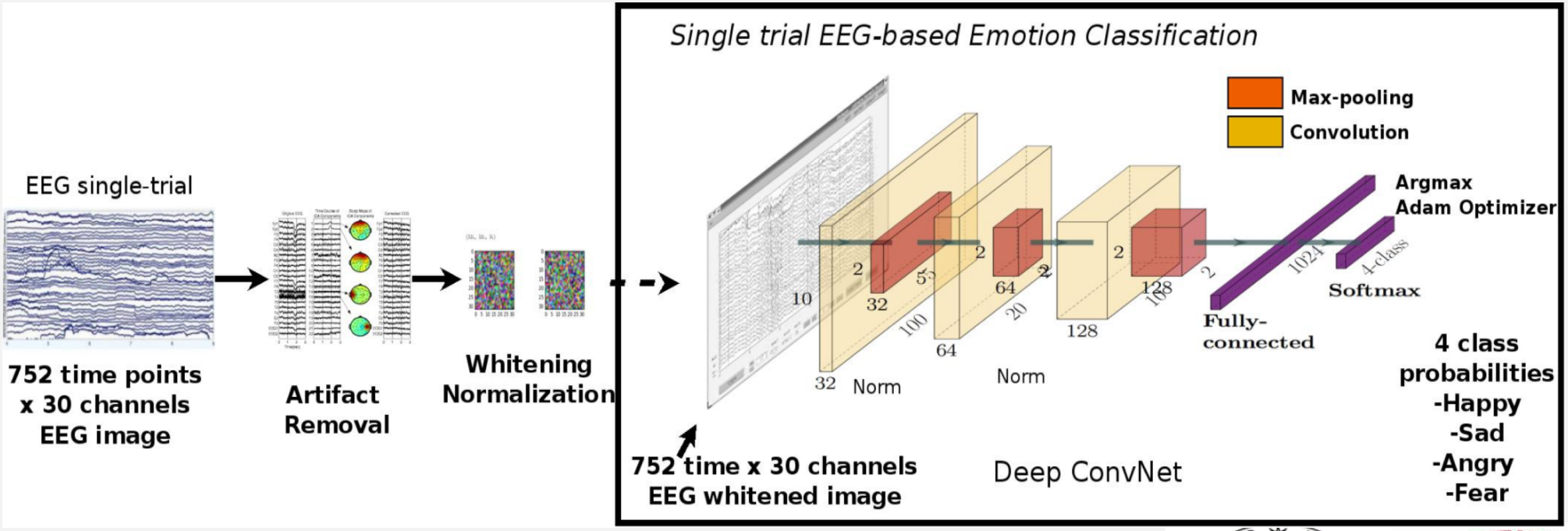
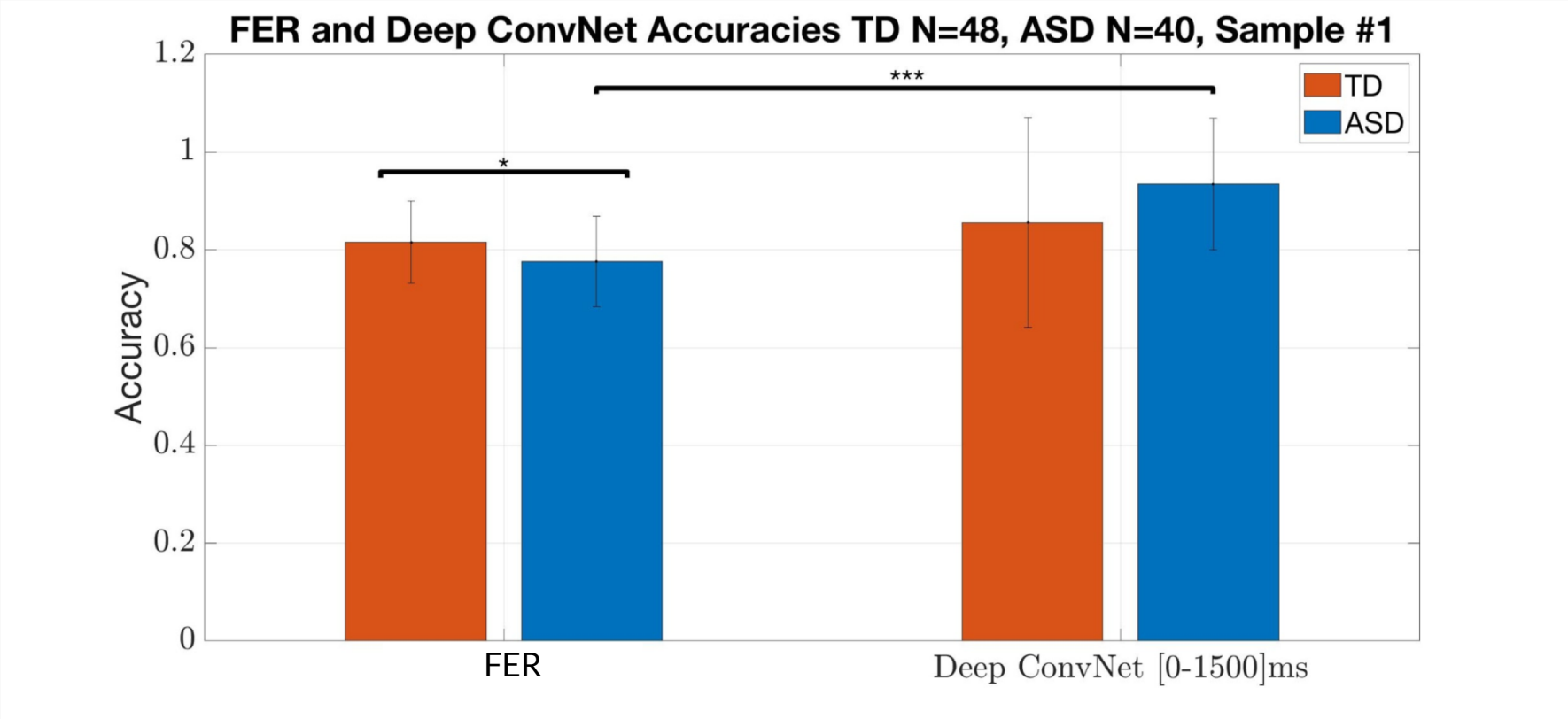


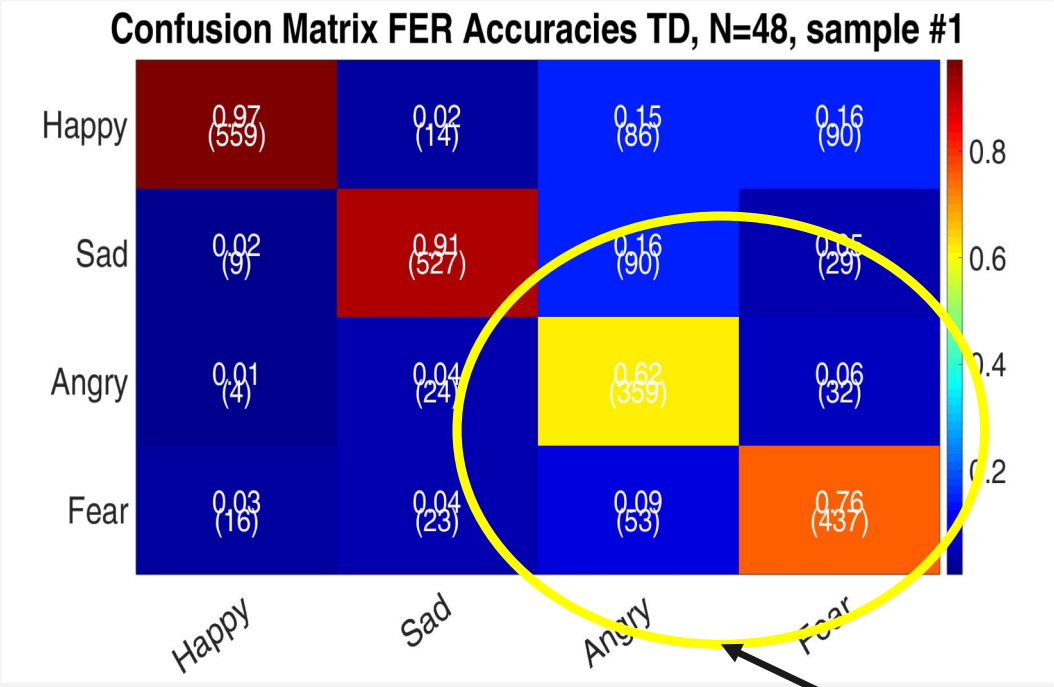
Emotion Decoding - Full Pipeline



Performance Results - Sample #1 TD N=48, ASD N=40

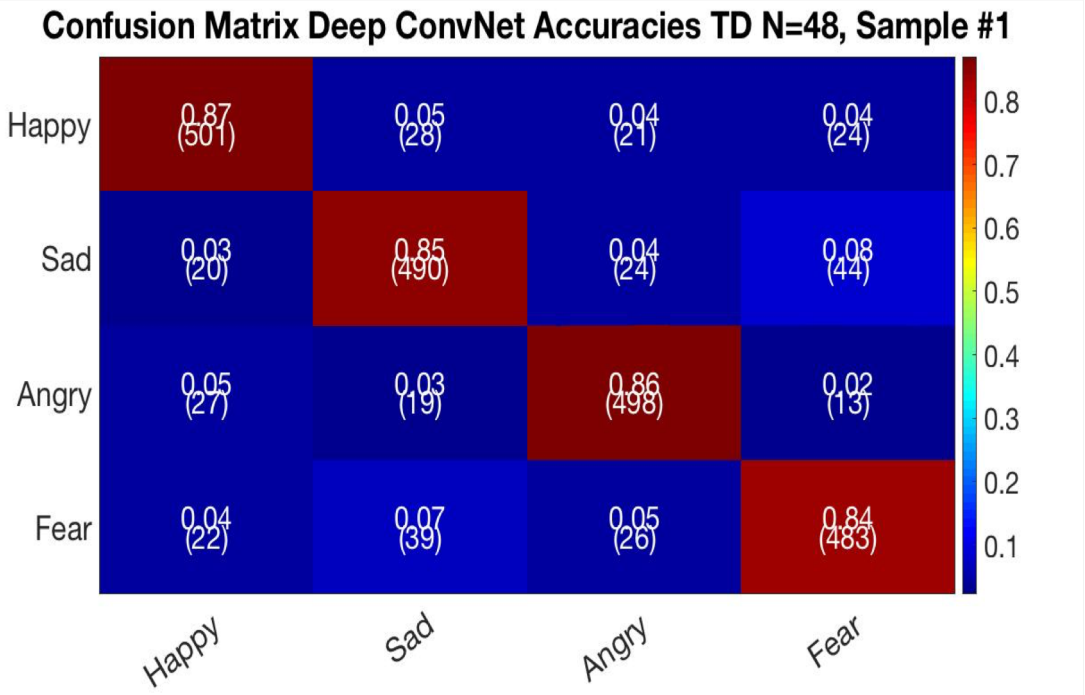


Performance Results - Confusion Matrix FER/Deep ConvNet TD



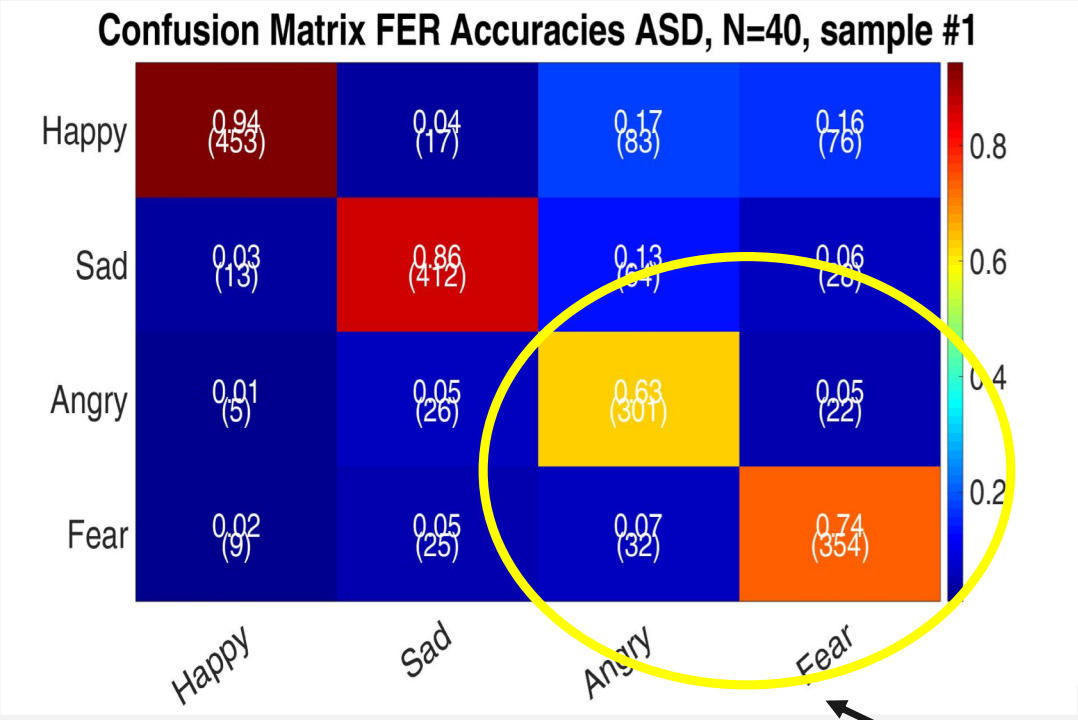
FER Human Conf Matrix

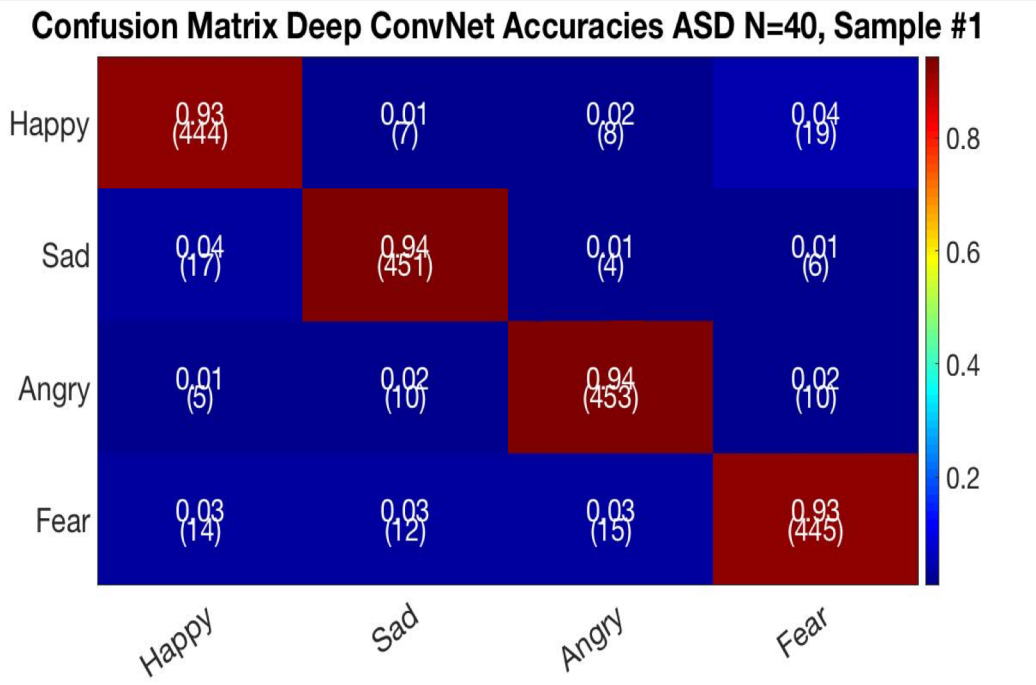
Negative emotions



Deep ConvNet Machine Conf Matrix

Performance Results - Confusion Matrix FER/Deep ConvNet ASD



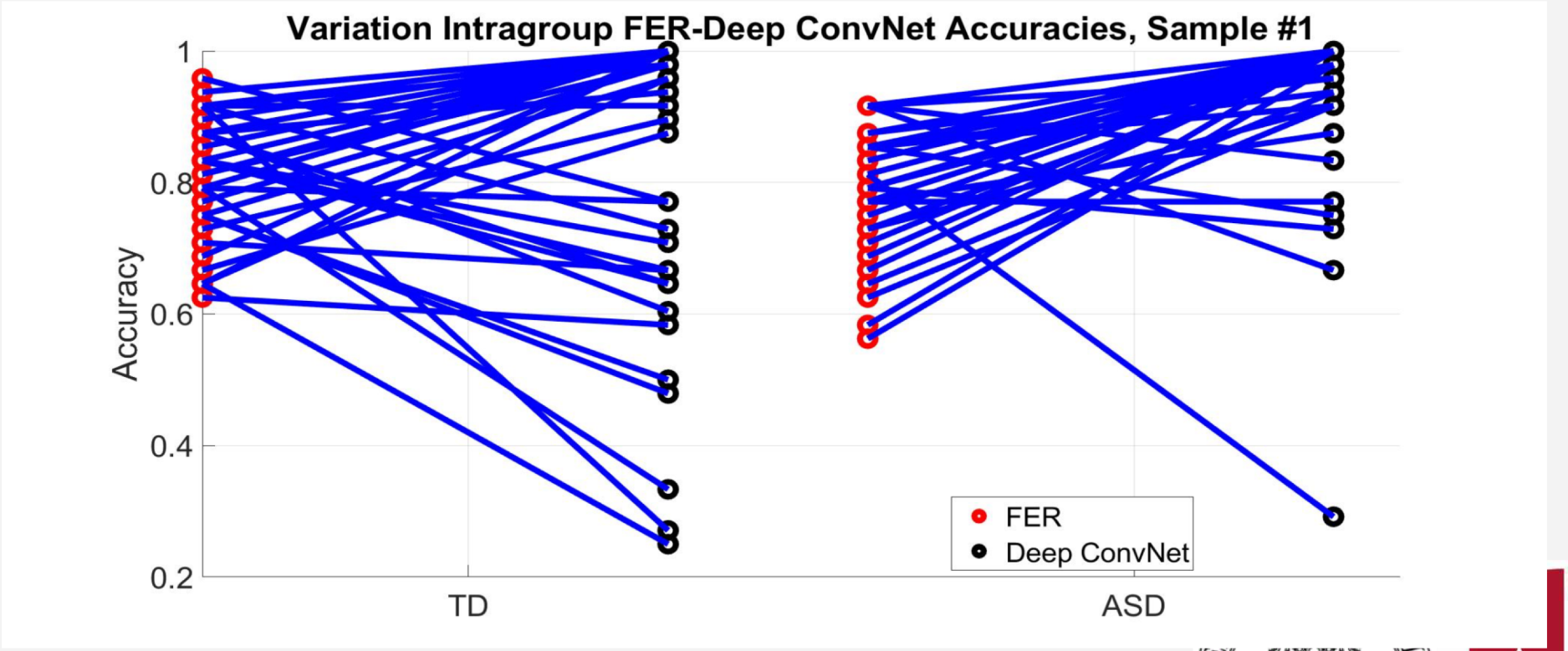


FER Human Conf Matrix

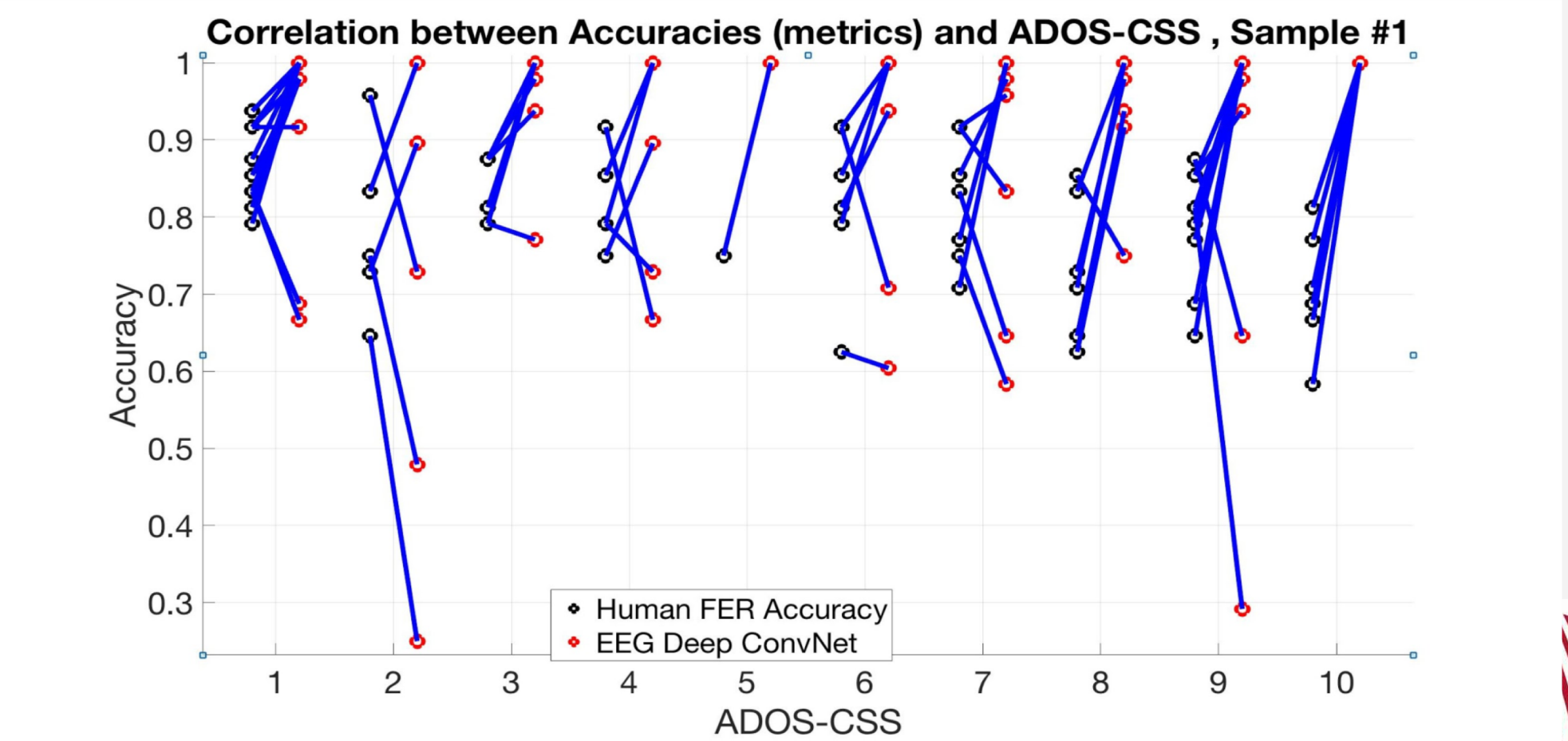
Negative emotions

Deep ConvNet Machine Conf Matrix

Performance Results - FER-Deep ConvNet intra-group



Performance Results - FER-Deep ConvNet-ADOS-CSS intra-group



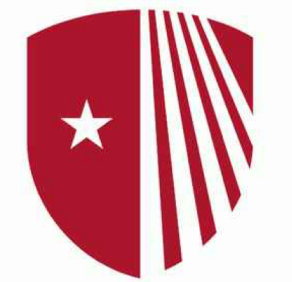
Can Deep Learning successfully decode emotion recognition from neural activity elicited by the viewing of faces? - answer question #1

- Deep ConvNets of EEG response in ASD and TD → similarly high performance in terms of correctly encoding FER
- ASD → significantly poorer behavioral performance on FER
  - Compared to TD
  - Compared to *their own* correct encoding
- **ASD → DO encode FER correctly!**
  - Do not reliably DEPLOY this information for FER judgement as expected

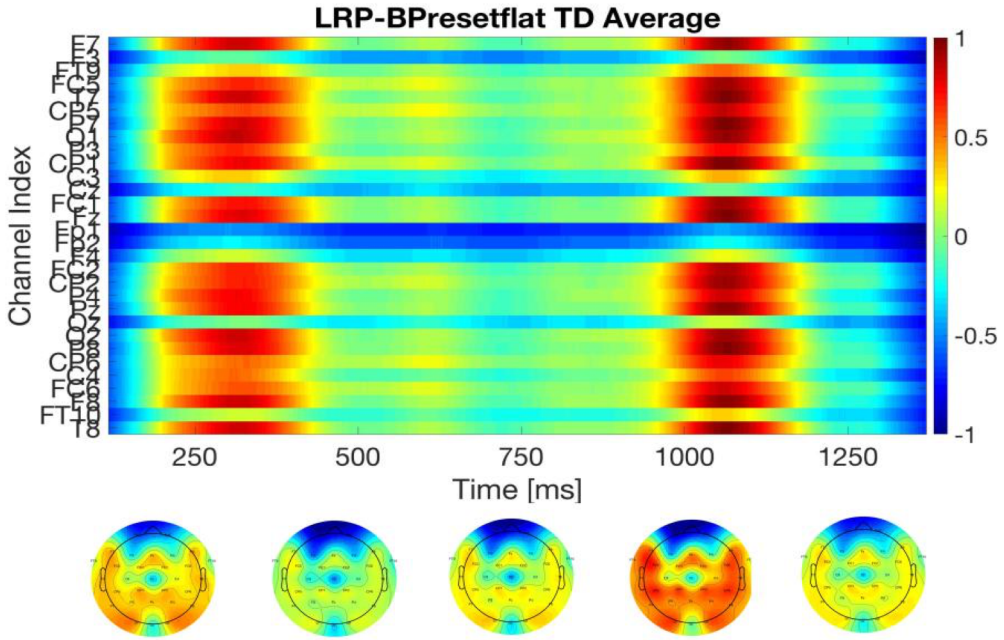
Questions and Hypothesis

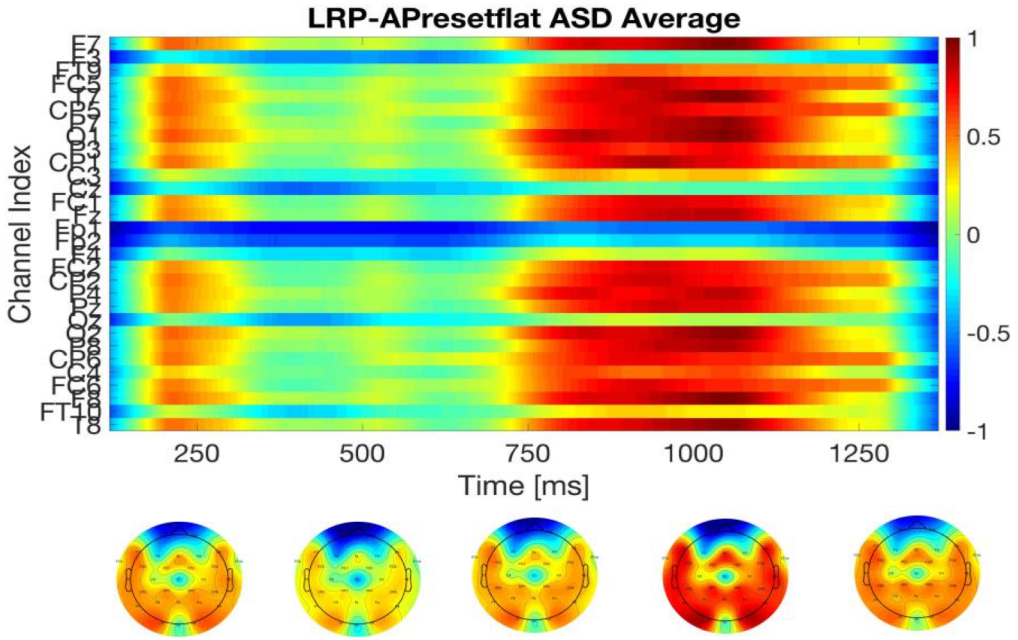
1. Are face emotion recognition (FER) deficits in ASD exhibited at the level of neural encoding?
    - Can Deep Learning successfully decode emotion recognition from neural activity elicited by the viewing of faces?

1. **What is distinct about the way individuals with ASD *are* encoding emotions, when and where do they do so?**



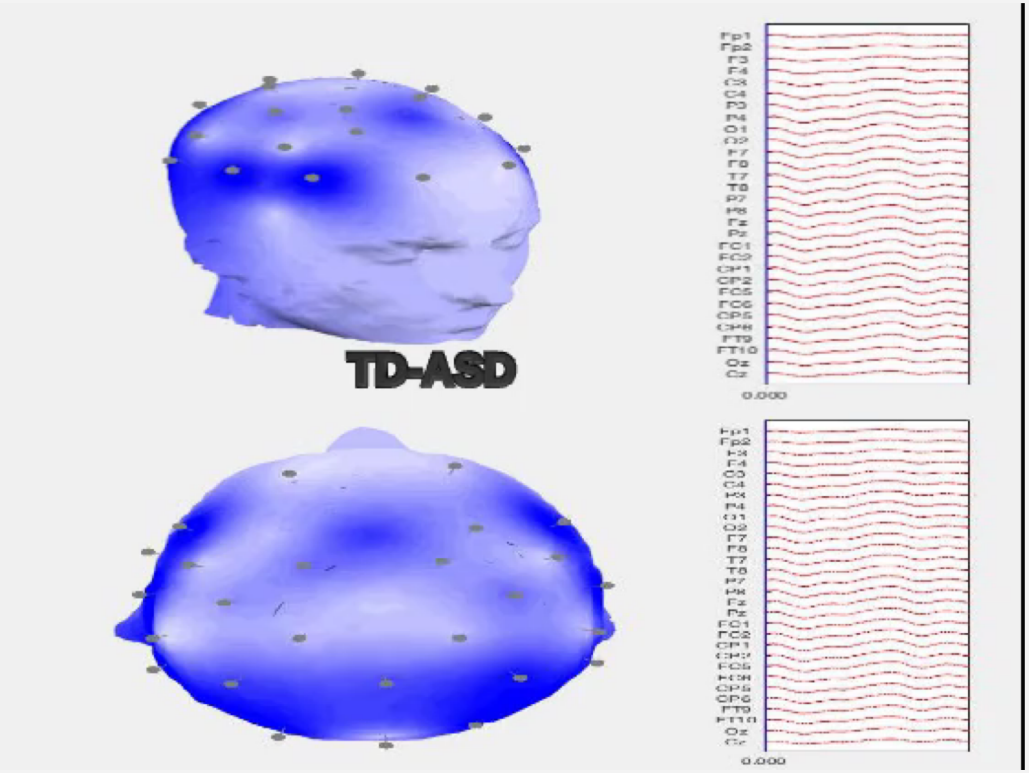
Feature Importance Results - Average LRP flat B preset TD



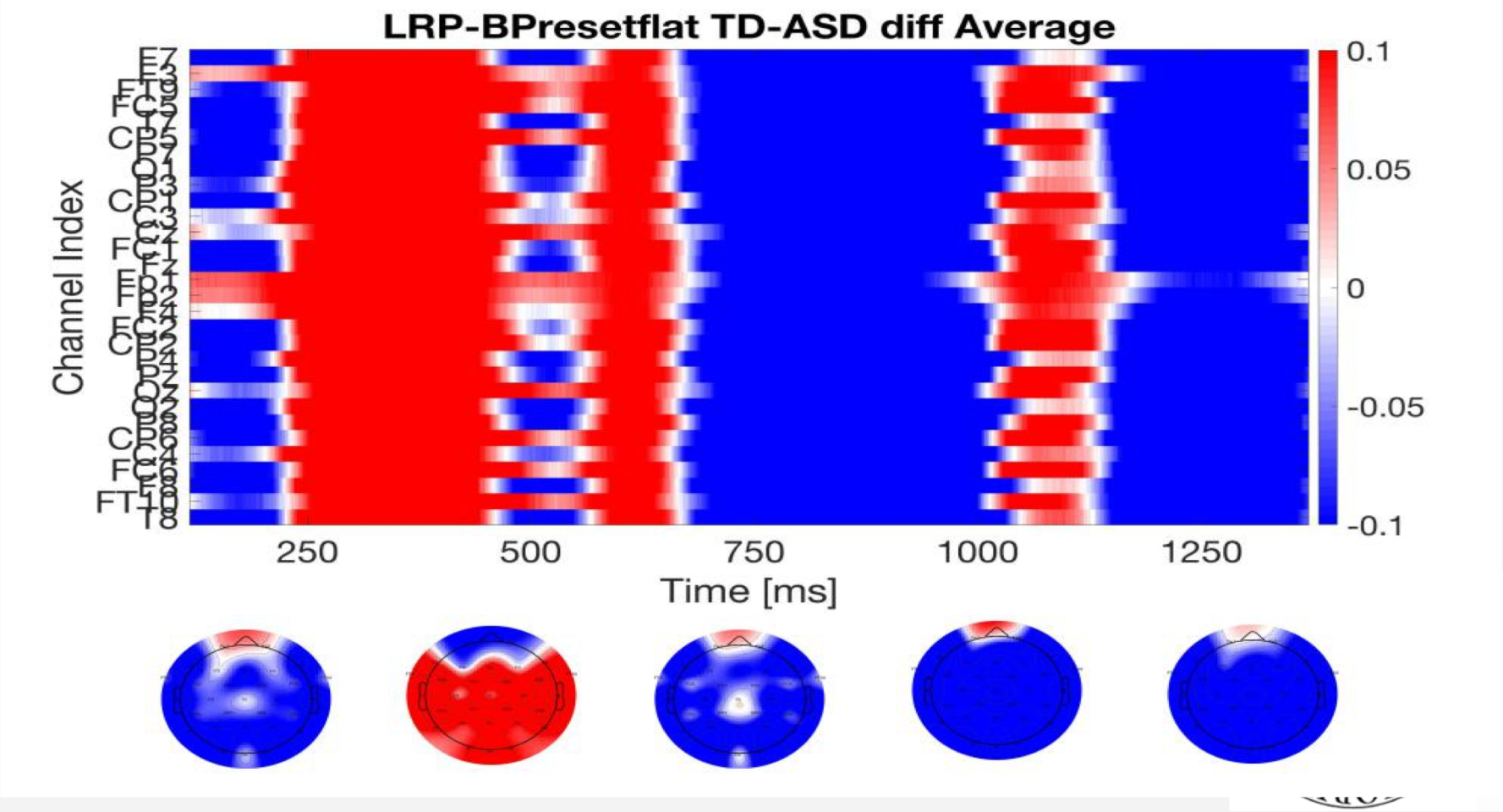


LRP B Preset is the most reliable method included in iNNvestigate package (P.J. Kiendermans et. al 2017, Montavon et. al 2018)

Feature Importance Results - Average LRP B flat preset TD-ASD differences



Feature Importance Results - Average LRP B flat preset TD-ASD



What is distinct about the way individuals with ASD *are* encoding emotions, when and where do they do so? - Answer question #2

- Identified which time windows (and channels) are **most relevant** for accurate FER encoding in ASD and TD
- Temporal distribution is somewhat *later* for ASD
    - **consistent** with previous findings related to **altered networks** activation presented in ASD groups.

Overall Study Conclusions and Broader Implications

- Deep ConvNet: **effective perceptual classifier** from EEG data
  - can successfully complete FER from TD and ASD groups
- No difference between ASD and TD at the level of encoding FER information.
  - Despite difference in behavior!
  - Replicates in multiple datasets
  - FER behavioral deficits in ASD → **translation**, no encoding
- Relevance pattern using reliable saliency maps → altered post-cognitive neural activation in ASD groups
- Interventions need ***not*** teach encoding
  - Should focus on ***gap*** between encoding and behavior





Dr-Ing Giuseppe Riccardi Matthew Lerner Ph.D Christian Luhmann Ph.D Tessa Clarkson Kathryn Hauschild Ph.D

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