Investigating the Roles of Fusiform Face Area and Occipital Face Area in Human Face Processing

a real-time fMRI neurofeedback study

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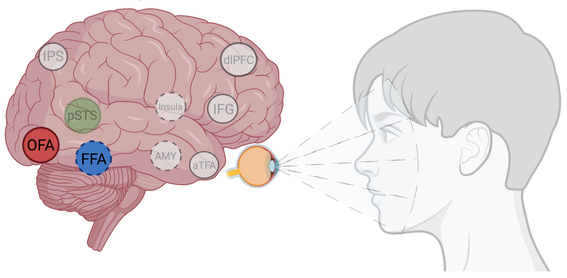
INTRODUCTION

Face Processing Networks



Hierarchical Model

- Occipital Face Area (OFA)
  - Initiation face processing
  - Early perception face features
  - **Face Detection(?)**
- Fusiform Face Area (FFA)
  - Higher level face processing
    - **Face Identification**

Non-hierarchical Model

- OFA
  - Fine-grained feature analysis
  - **Face Identification**
- FFA
  - Initiation of face processing
  - **Face Detection** by means of holistic categorization
  - **Face Identification**
    - OFA input for fine-grained feature analysis

Goal of the study

To dissect the differential roles of OFA and FFA by manipulating their activity in real-time with fMRI-NFB and observing behavioral effects during a face detection & recognition task.

- Hierarchical Model
  - OFA → Detection || FFA → Recognition
- Non-hierarchical model
  - FFA → Detection + Recognition || OFA → Recognition

METHODS

Protocol & Paradigm

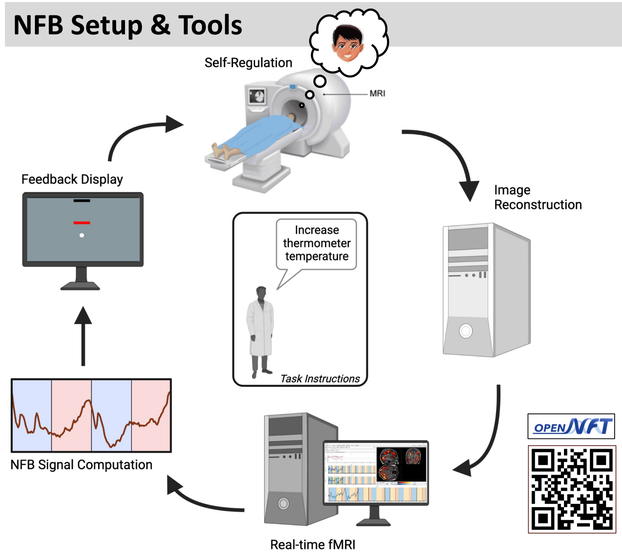
Session 1	Session 2
- Briefing	- Questionnaire
- Questionnaires	- Session to Session Coregistration
- T1	- **NFB (7 runs)**
- Functional Localizer	- Debriefing
- ROI delineation	
- **NFB (7 runs)**	

Participants
- Experimental group (EXP): N = 22
- Control Group (CONT): N = 20

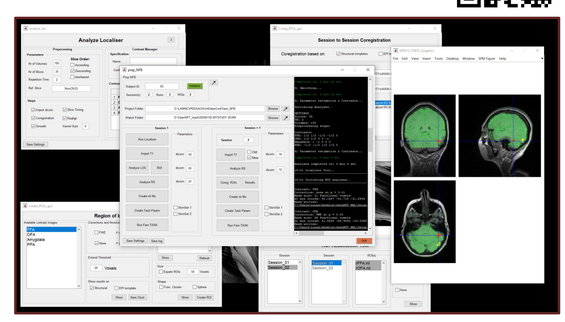
Two training sessions:
- Session 1: FFA > OFA
- Session 2: OFA > FFA

Each Session:
- 7 runs of 7 trials (49 trials, 60 min total)

NFB Setup & Tools

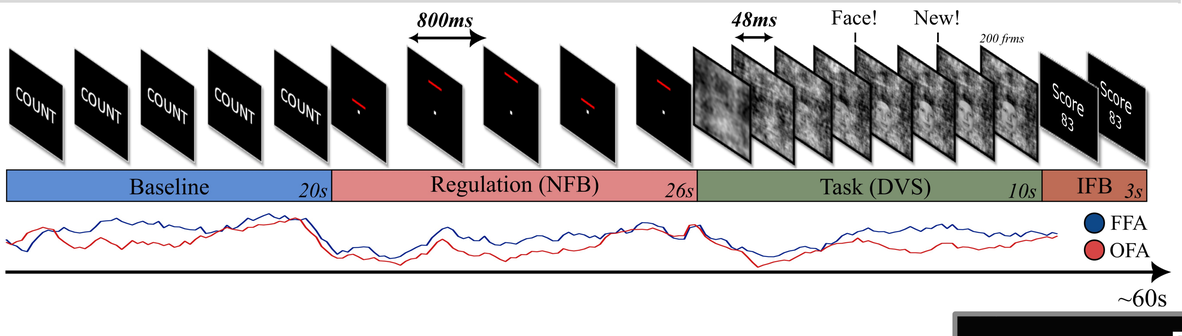


prepNFB

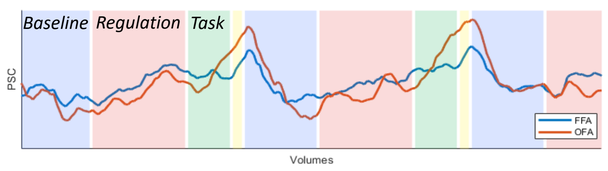


MATLAB based toolbox to prepare for, and co-register between OpenNFT Neurofeedback session(s).

Single NFB Trial



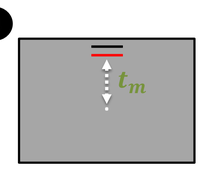
Neurofeedback Computation & Visualization



1. $$PSC = \frac{mean(ROI_{Reg(t-2:t)}) - median(ROI_{AccBas})}{median(ROI_{AccBas})}$$

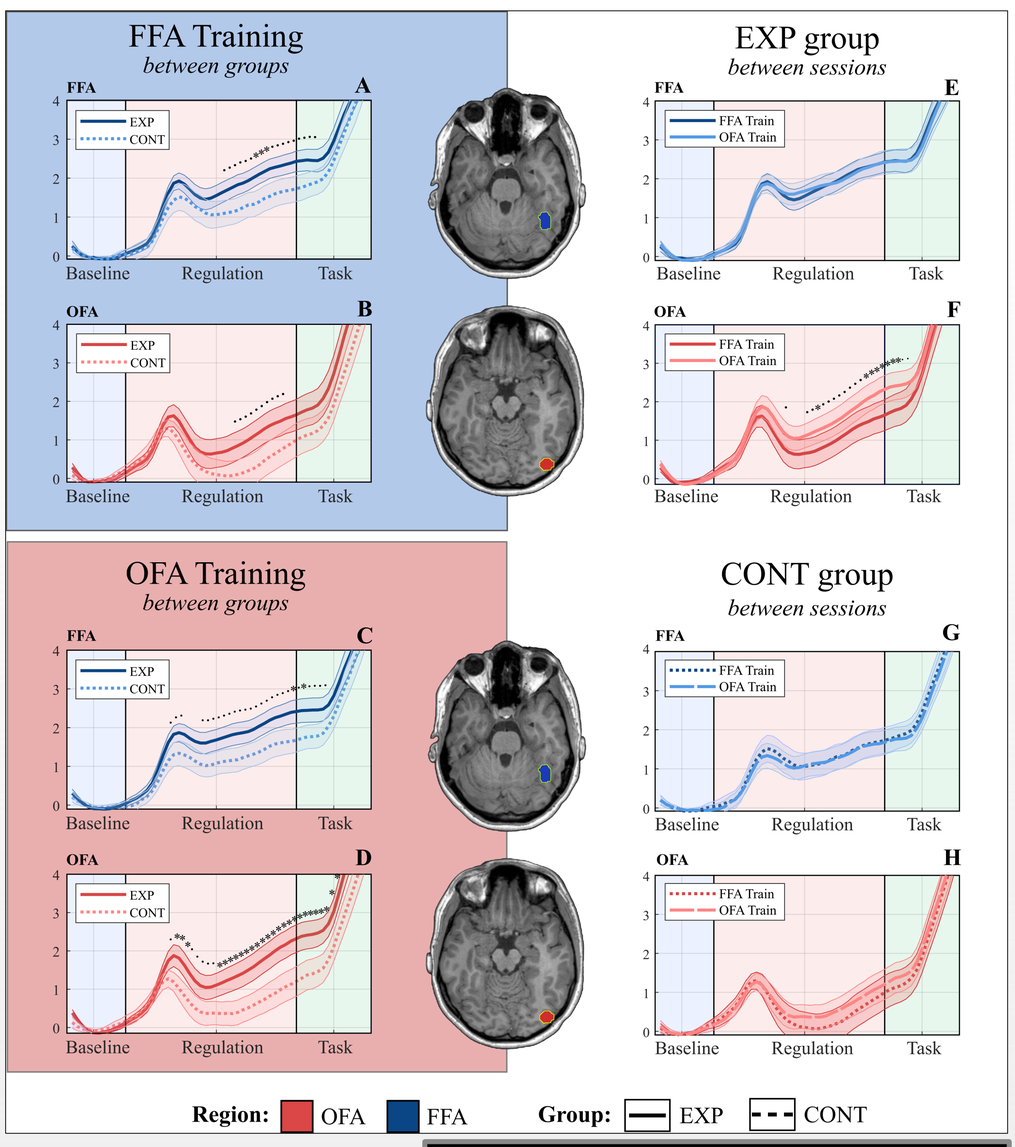
2. $$diffPSC = PSC_{ROI1} - PSC_{ROI2}$$

3. $$t_m = \frac{diffPSC - limit_{low}}{limit_{up} - limit_{low}} * (step_{max} - step_{min}) + step_{min}$$

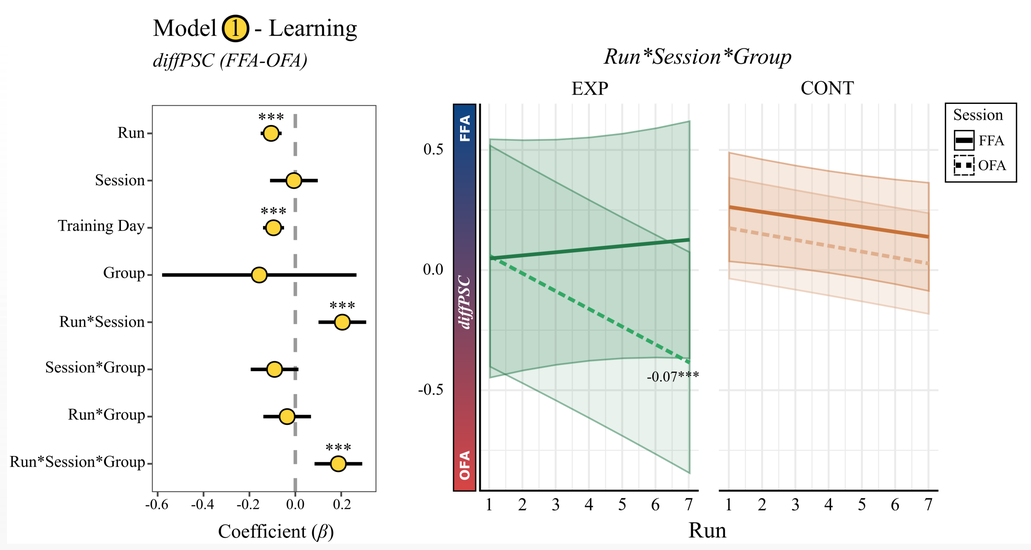
4. 

RESULTS

1. Neurofeedback Performance: Session Effects



2. Neurofeedback Performance: Learning

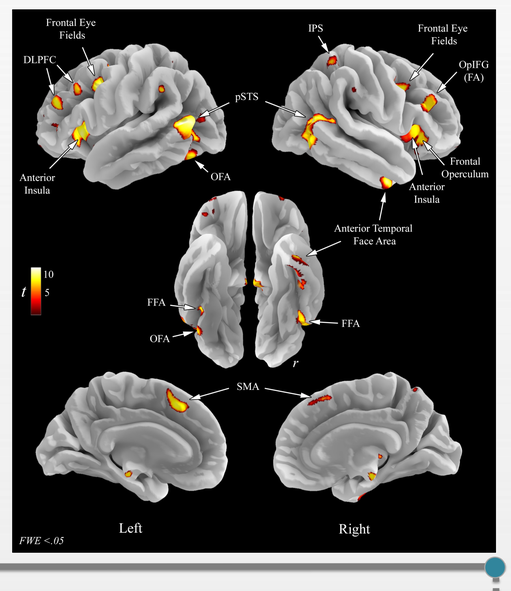


Linear Mixed Model:

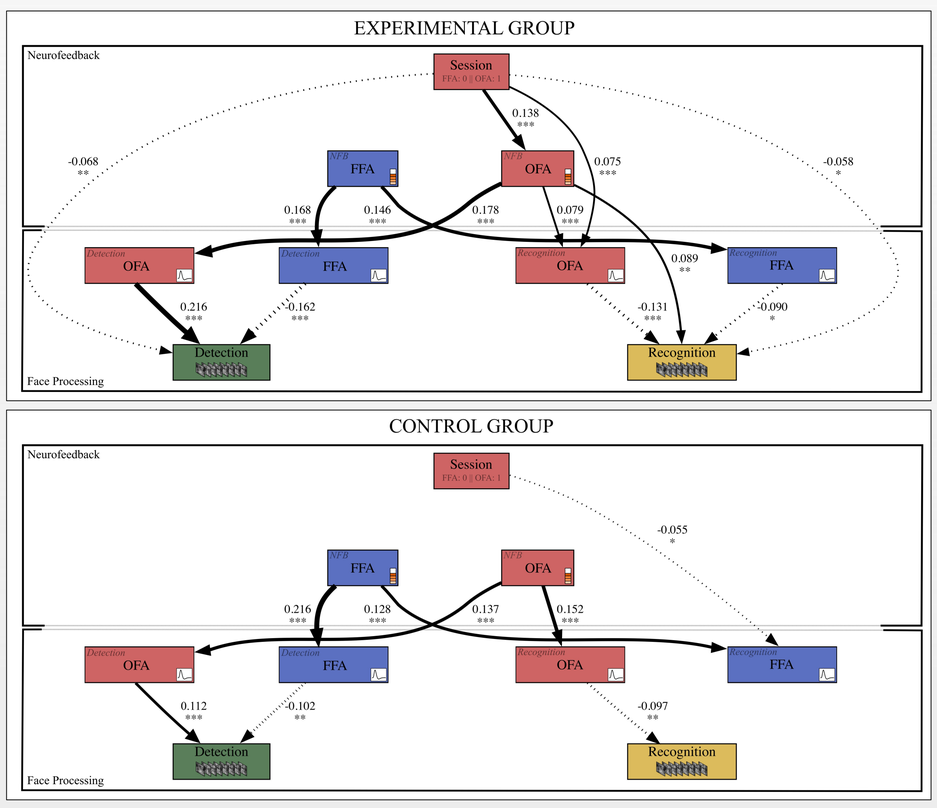
*diffPSC ~ Run + Session + Day + Group + Run*Session*Group + (1|subID) + (1|stimID)*

- EXP group increases its regulation performance across runs.
- Learning is strongest in the OFA session.
- No learning is seen in the CONT group.

3. Whole Brain Regulation Activity



4. Path Analysis using SEM



CONCLUSIONS

1. Participants in the experimental group successfully modulated **Occipital Face Area** activity during the *OFA training session* as well as **Fusiform Face Area** activity during the *FFA training session*:
   - OFA activity during the OFA session was significantly higher when compared to:
     - OFA activity of the Control group **(1D).**
     - OFA activity in the FFA session **(1F).**
   - FFA activity during the FFA session was significantly higher when compared to:
     - FFA activity of the Sham group **(1A).**
2. Participants in the experimental group showed strong signs of learning mostly during the OFA session.
   - Consistent increase in OFA dominance during OFA training session **(2)**.
   - Modest (ns.) increase in FFA dominance during FFA training session **(2)**.
3. Self-regulation in the EXP group consistently engaged the core and extended face processing networks **(3)**.
4. FFA activity improves face detection *and* face recognition abilities. OFA activity impairs face detection but enhanced face recognition performance **(4)** → **Non-hierarchical face processing models**

References:

1. Haxby, V. H. et al. (2000). The Distributed Human Neural System for Face Perception. *Trends in Cognitive Sciences, 4, 223-233.*
2. Rossion, B. (2014). Understanding face perception by means of prosopagnosia and neuroimaging. *Frontiers in Bioscience, 6,* 258–307.
3. Tsao, D. Y., Livingstone, M. S. (2008). Mechanisms of Face Perception. *Annual Review of Neuroscience, 31(1),* 411-337.
4. Solomon-Harris, L.M. et al. (2013). TMS to the occipital face area affects recognition but not categorization of faces. *Brain and Cognition, 83(3),* 245-251.
5. Face Processing and NFB-Setup figures created using BioRender.com