Enhancing Subliminal Perception With Real-Time fMRI Neurofeedback

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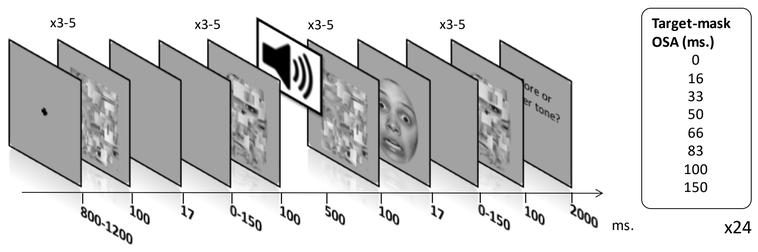
INTRODUCTION

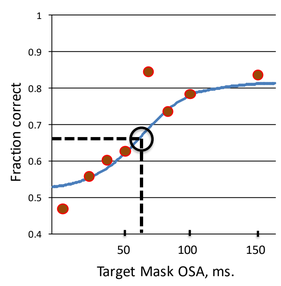
- Subliminally presented face stimuli in masking paradigms evoke fusiform face area (FFA) activity[1].
- Using a novel fMRI-based neurofeedback[2] protocol we trained 20 healthy volunteers to enhance right FFA activity evoked by subliminally presented[3] *fearful* faces.
- A matched control group of 19 subjects was trained to upregulate right intra parietal sulcus (IPS) activity while being exposed to the same training protocol.

Aim of the study:

1. Can healthy subjects learn to enhance subliminal neural activity in the right FFA?
2. If yes, will this learned ability enhance:
   a) Behavioral detection of subliminally presented faces.
   b) Neural responses to subliminally presented faces.

Subject-specific subliminal detection thresholds





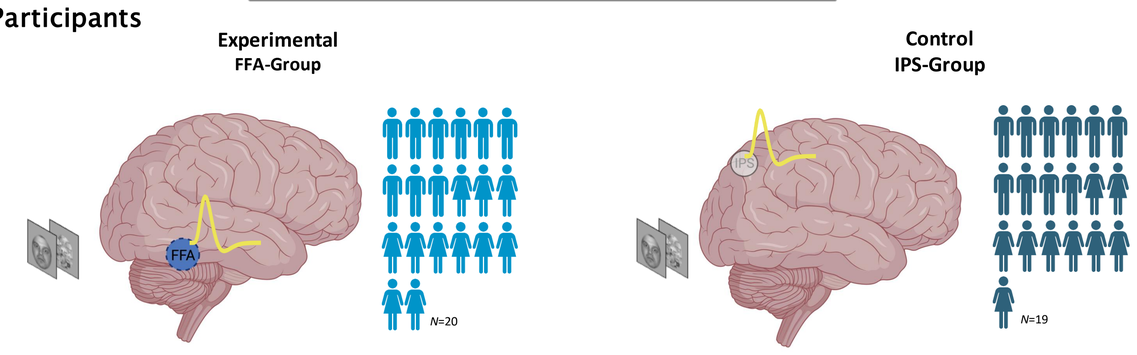
Estimate detection threshold pre- and post NFB training

- Fit psychometric curve to subject data
- Inflexion point = est. detection threshold

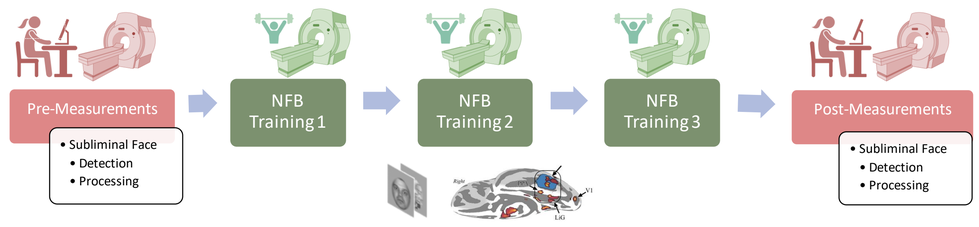
$$f(x) = \alpha_1 + \frac{\alpha_2}{1 + e^{-\alpha_3(x-\alpha_4)}}$$

METHODS

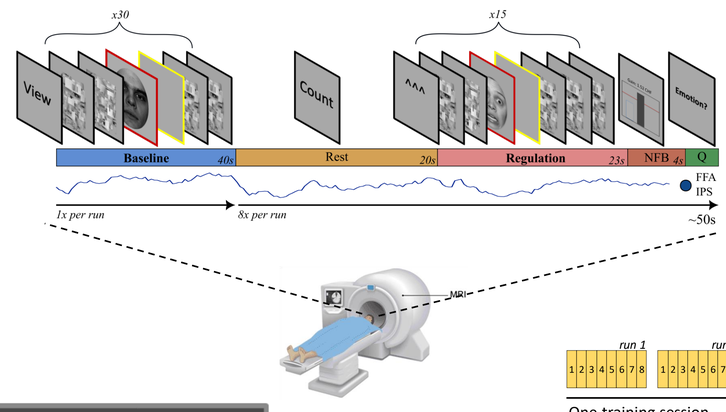
Participants



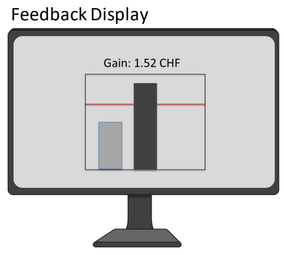
Protocol



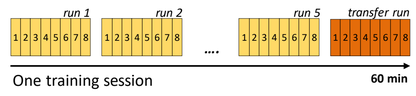
NFB Training



Feedback Display



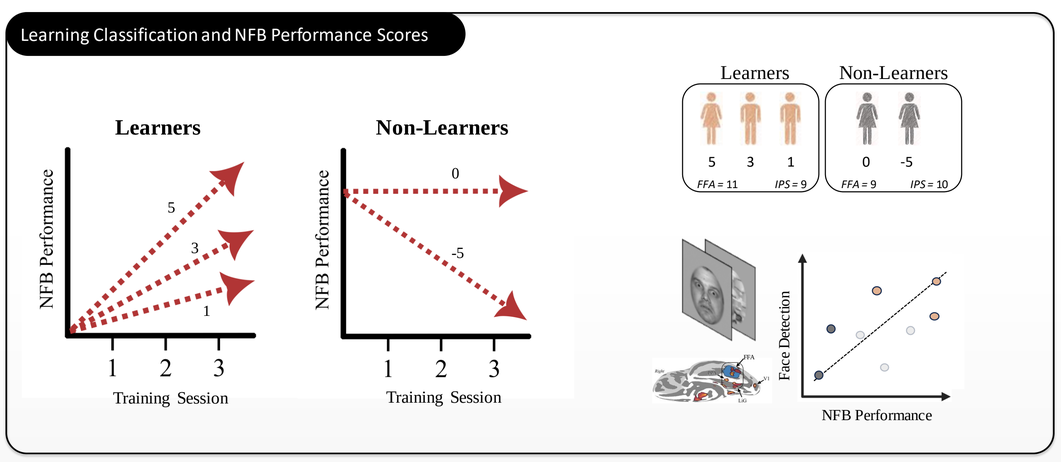
$$FB\ value = \frac{mean(ROI_{regulation}) - mean(\sum ROI_{baseline})}{\sum SD_{baseline}}$$

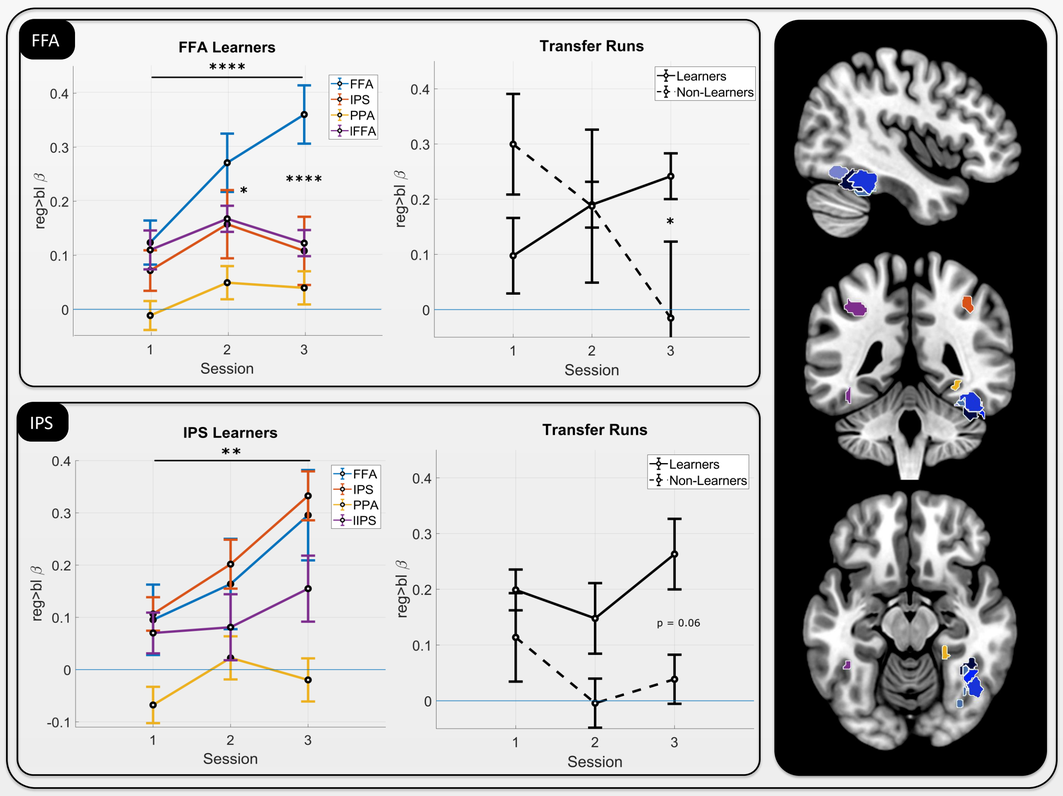


RESULTS

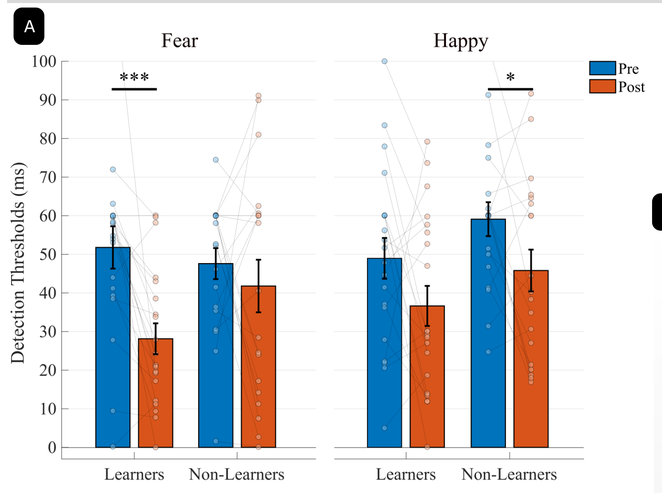
1. NFB Learning: Learners and Non-Learners

Learning Classification and NFB Performance Scores

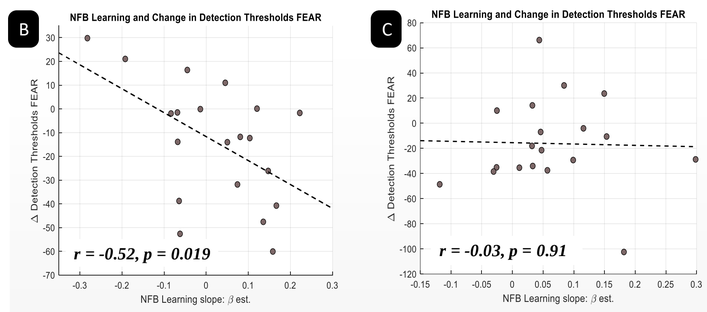




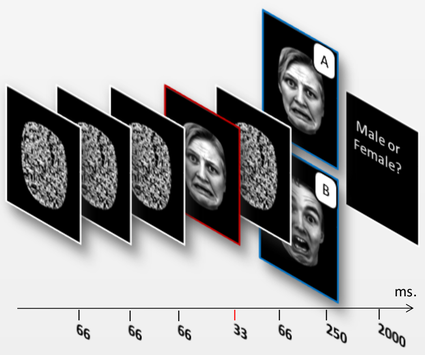
2. Pre versus post subliminal detection thresholds



A) The IPS- and FFA-*learners* both improved their fear face detection (SDTs) after NFB-training (no differences). **B)** But only in the FFA-trained group was NFB-learning associated with these improvements, where better NFB- learning resulted in enhanced fear face detection. **C)** This was not the case in the IPS-trained group.



3. Changes in functional processing of subliminal faces – Repetition Suppression

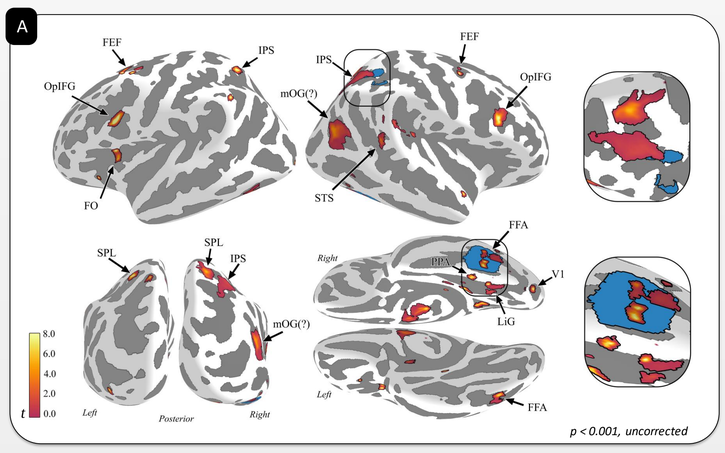


Subliminal Repetition Suppression

Conditions
A. Congruent (prime = target)
B. Incongruent (prime ≠ target)

Repetition suppression effect:
❖ Congruent < Incongruent

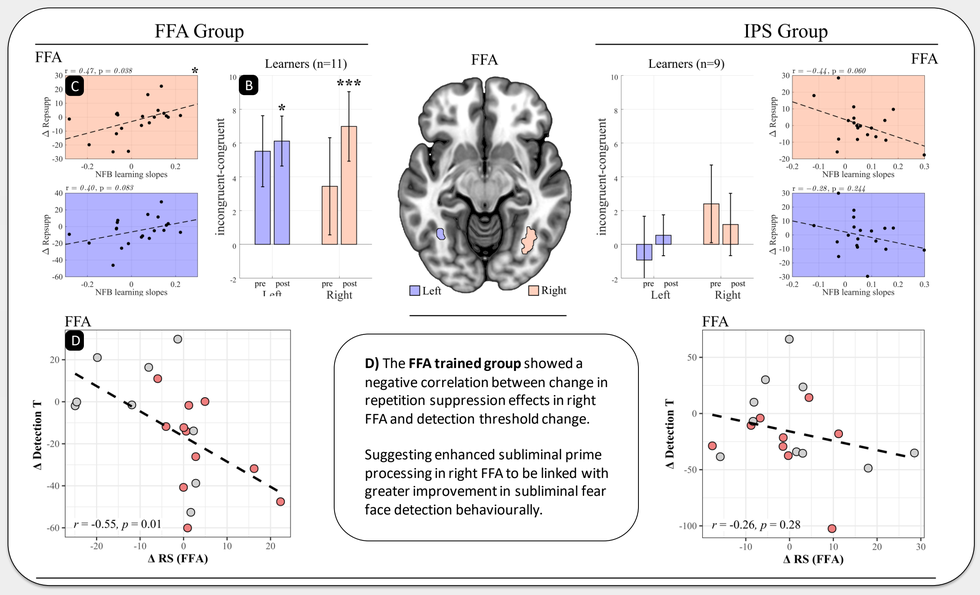
Enhanced processing of subliminal faces:
❖ Greater repetition suppression effect *after* NFB training



A) Face repetition priming *before* NFB training was observed in both IPS and FFA (both groups; *n*=39).

B) *Only* the **FFA-learners** (*n*=11) showed an increased fear-specific RS-effects in *rFFA* post-training.

C) FFA-group (*n*=20): those who benefited most from training also exhibited the strongest increases in subliminal face priming



D) The **FFA trained group** showed a negative correlation between change in repetition suppression effects in right FFA and detection threshold change.

Suggesting enhanced subliminal prime processing in right FFA to be linked with greater improvement in subliminal fear face detection behaviourally.

CONCLUSIONS

Our findings show that FFA-targeted training heightened subliminal fear faces processing in FFA, which translated to an enhanced ability to detect similar subliminal faces post-training.

- Participants in both groups learned to enhance (subliminal) neural activity in their target ROIs **(1)**.
- Only in the **FFA trained** group was *NFB learning* related to improved detection of subliminally presented faces:
  - **Behaviorally (2):** Better NFB- learning corresponded to enhanced fear face detection performance **(2B)**.
  - **Neurally (3):** Better NFB- learning corresponded to enhanced processing of subliminal faces in the right FFA **(3C)** which in turn correlated with improved detection thresholds post-training **(3D).**

fMRI-NFB shows promise for amplifying responses to unseen stimuli, applicable to neglect and blindsight.

References:

1. Brooks, S. J. et al. (2012). Exposure to subliminal arousing stimuli induces robust activation in the amygdala, hippocampus, anterior cingulate, insular cortex and primary visual cortex: a systematic meta-analysis of fMRI studies. *NeuroImage, 59,* 2962-2973.
2. Thibault, R. T., et al. (2018) Neurofeedback with fMRI: A critical systematic review. *NeuroImage, 172,* 786-807.
3. Del Cul, A. et al. (2009). Preserved subliminal processing and impaired conscious access in schizophrenia. *Arch Gen Psychiatry, 63,* 1313-1323..