Regulating subliminal neural activity in the fusiform face area: a fMRI-based neurofeedback study

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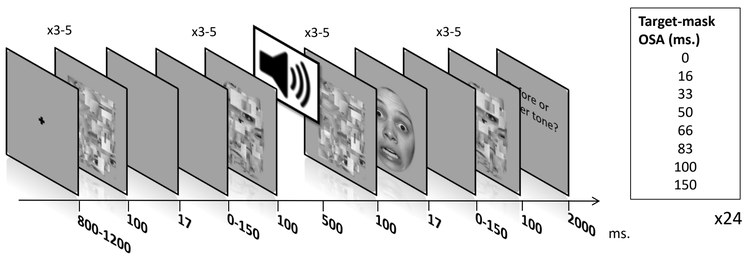
INTRODUCTION

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

Aim of the study:

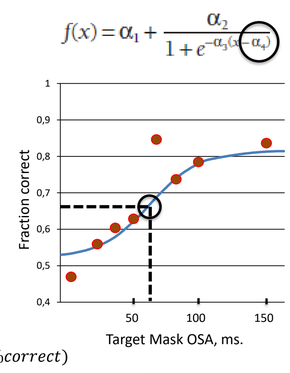
1. Can healthy subjects learn to enhance subliminal neural activity in the right FFA?
2. If yes, will this learned ability enhance:
   a) Behavioral detection of subliminally presented faces.
   b) Neural responses to subliminally presented faces.

Subject-specific subliminal detection threshold and d' estimate



Target-mask OSA (ms.)
0
16
33
50
66
83
100
150

x24

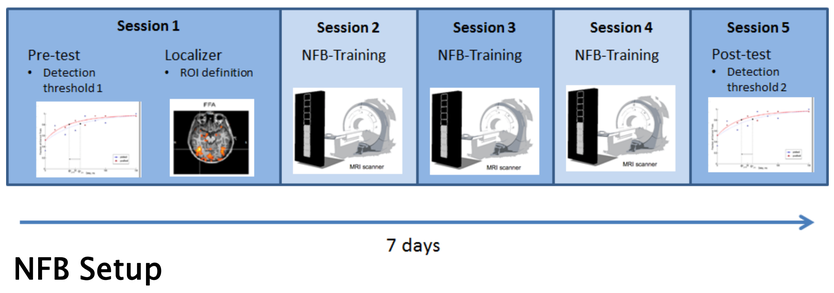


Estimate d' at detection threshold pre- and post NFB training
- **Fit psychometric curve to data**
- **Inflexion point = est. detection threshold**
- **Estimate d' based on % correct at threshold**

$d'_{est.} = \sqrt{2} * inverseNormalCDF(\%correct)$

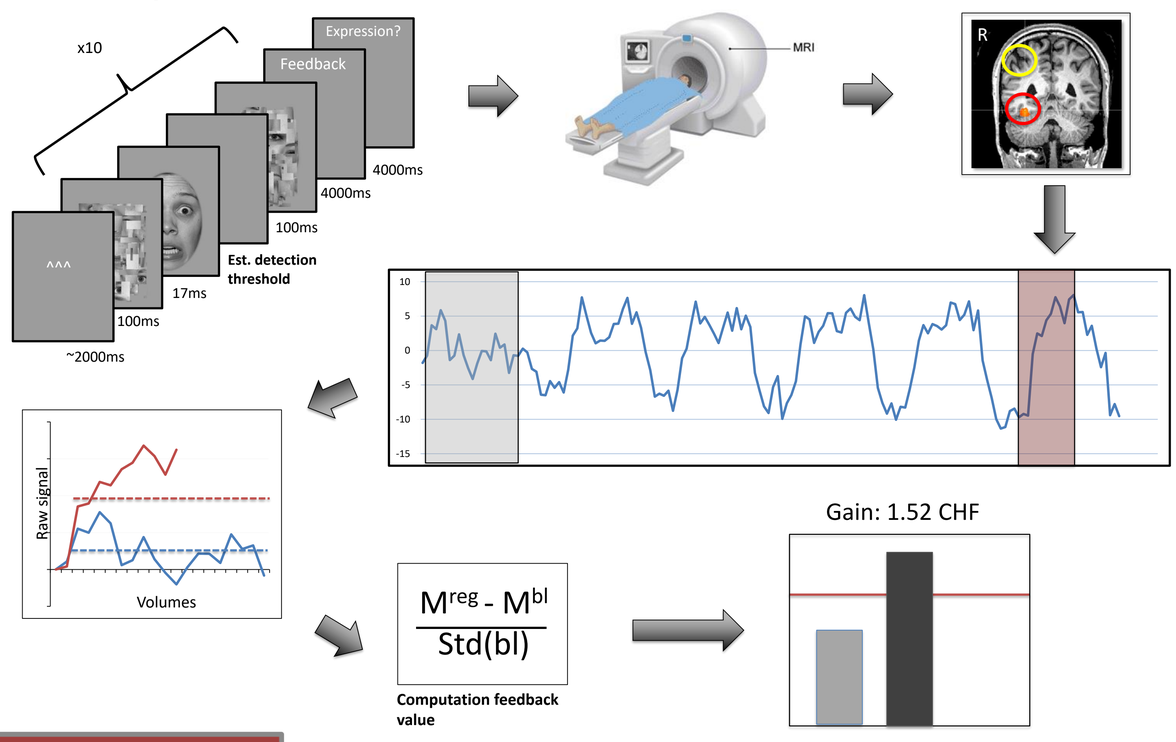
METHODS

Protocol



NFB-Training:
- **3 sessions**
- **Per session 5 runs + 1 transfer run**
- **Each run: One 40 sec. baseline and 9 regulation blocks**

NFB Setup

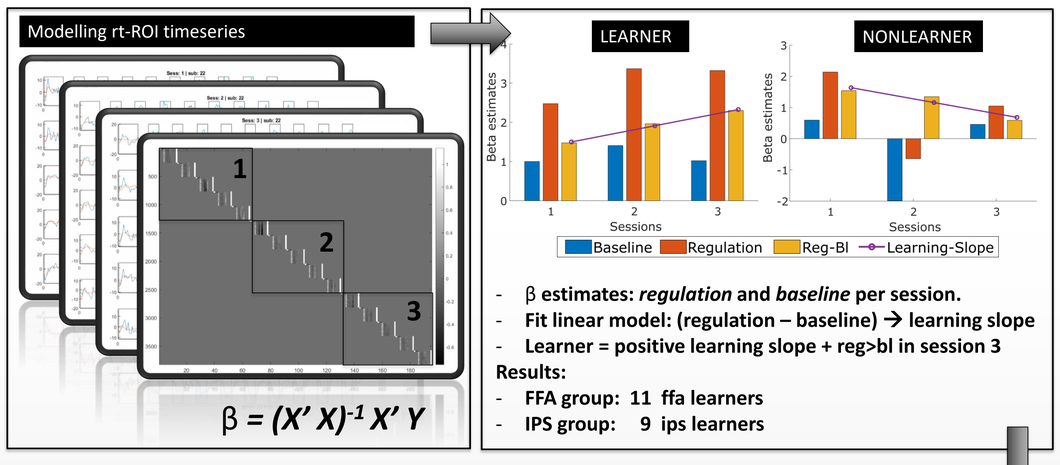


$$\frac{M^{reg} - M^{bl}}{Std(bl)}$$

Computation feedback value

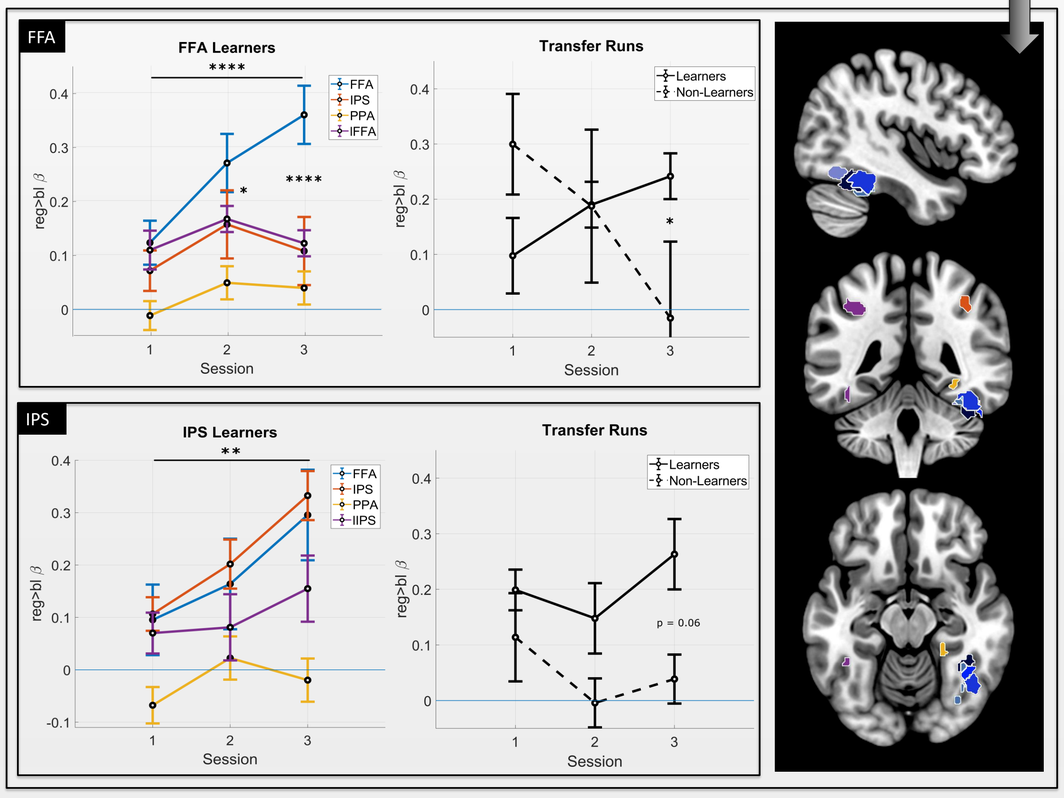
RESULTS

A. FFA and IPS learners versus non-learners

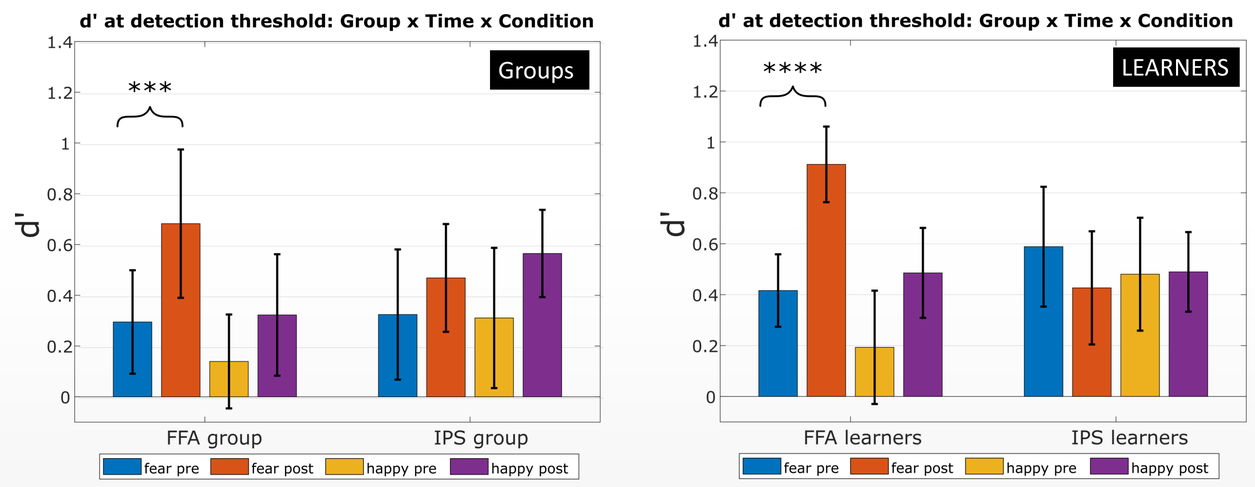


- **β estimates: *regulation* and *baseline* per session.**
- **Fit linear model: (regulation – baseline) → learning slope**
- **Learner = positive learning slope + reg>bl in session 3**

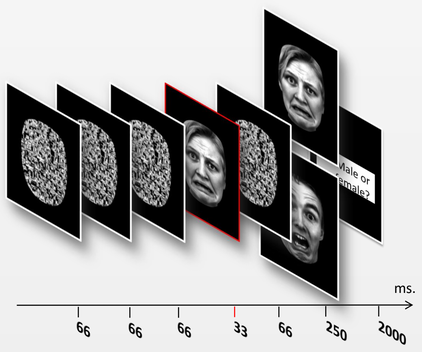
Results:
- **FFA group: 11 ffa learners**
- **IPS group: 9 ips learners**



B. Pre versus post d' at subliminal detection threshold



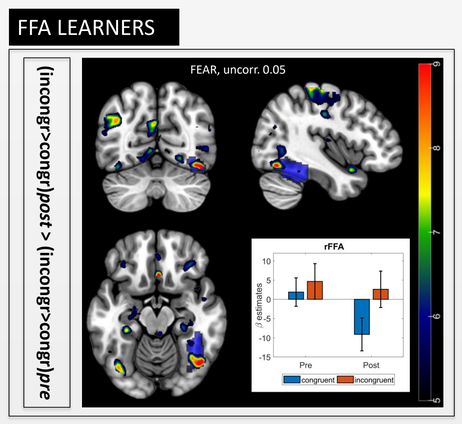
C. Changes in functional processing of subliminal faces

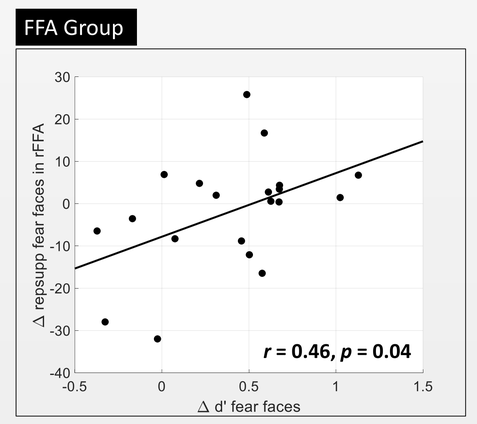


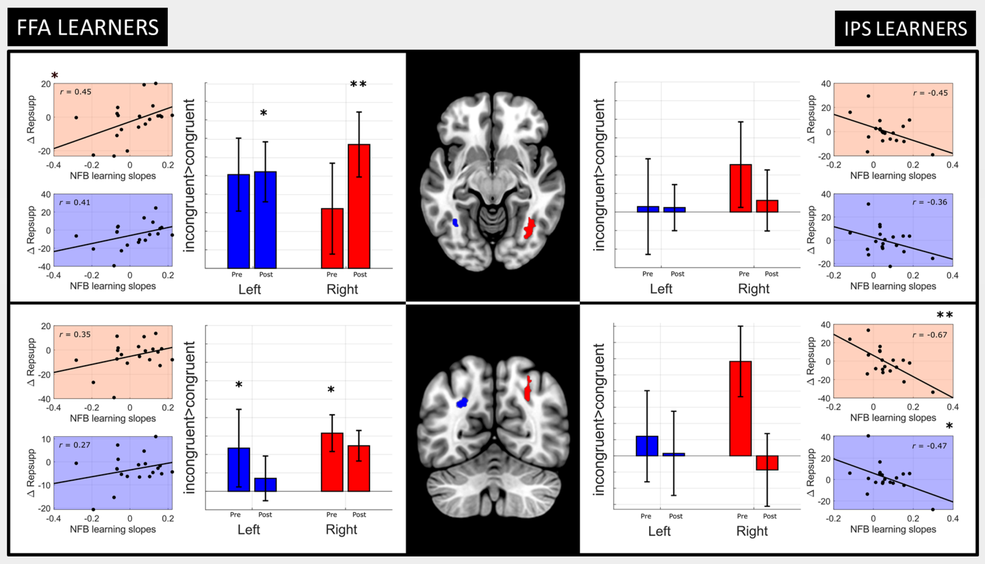
Subliminal Repetition Suppression Task
- **Congruent condition (prime = target)**
- **Incongruent condition (prime ≠ target)**

Repetition suppression effect:
- **Congruent < Incongruent**

***Enhanced* processing of subliminal faces**
- **enhanced repetition suppression effect**







CONCLUSIONS

- **Healthy subjects can learn to enhance subliminal neural activity in the right FFA**
  - FFA group: 11/20 subjects were able to significantly increase subliminal right FFA responses (FFA learners).
  - IPS group: 9/19 subjects were able to significantly increase right IPS activity (IPS learners).
- **NFB learning is related to improved behavioral detection of subliminally presented faces**
  - The FFA group (but not the IPS group) significantly improved subliminal detection of fear faces. This effect was driven by the FFA learners. In contrast, IPS learning was not related to improved detection.
- **NFB learning is related to enhanced neural responses to subliminally presented faces**
  - The FFA learners (but not the IPS learners) showed an enhanced repetition suppression effect for fearful faces in the FFA. This suggests that subliminal primes were processed to a greater extend *after* NFB-training. Importantly, this effect was most prominent in the (trained) right FFA where it was also positively correlated with both the NFB learning slope AND the behavioral change in subliminal detection.

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..