IT'S AN ILLUSION – OR HOW OUR BRAIN MAKES US BELIEVE IN SEEING THINGS THAT ARE NOT THERE

LABORATORY for MULTIMODAL NEUROIMAGING

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INTRODUCTION

Visual perception is based on the integration of endogenous top-down with sensory bottom-up processes. While sensory processes in the occipito-temporal cortex during the visual perception of objects have been studied intensively throughout the last decades, the knowledge about neural correlates of top-down processes is sparse. In a previous functional magnetic resonance imaging (fMRI) study, we used an illusory face detection task to study the neural mechanisms associated with the detection of a face [1]. In the present study, we aimed to generalize our findings. Thus, we investigated the neural network and specifically the top-down mechanisms associated with the illusory detection of letters, as one specific example of non-face objects.

METHODS

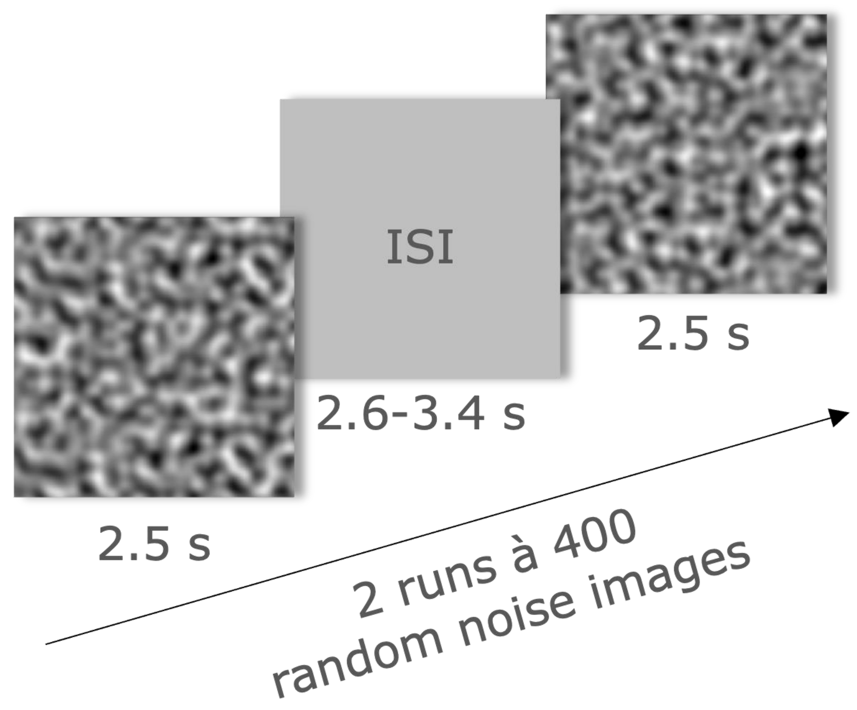

***Fig. 1:** Illusory letter task.*

Paradigm and subjects:
To trigger illusory letter perception, 20 subjects (11 women), mean age 23.3 years (SD = 2.7 years), were presented with 800 random noise images, equally divided over two fMRI sessions. Subjects were led to believe, that letters would be present on half of the trials. After each stimulus, subjects indicated whether they had perceived a letter or not.

Data aquisition & analysis:
Functional fMRI data were acquired on a Siemens 3-Tesla TIM-Trio MR scanner (TR = 1.45 s, 3x3x4 mm, 30 slices); University of Marburg. Functional data were preprocessed using standard routines and then analysed by means of a first-level general linear model (SPM12). The individual contrasts were entered in a random-effects group analysis.
Psychophysiological Interaction (PPI) analysis (generalized PPI (gPPI) toolbox [2]) was used to reveal functional connectivity patterns.
Hemispheric lateralization was assessed with a lateralization index (LI). LIs were calculated using the bootstrap procedure implemented in the LI toolbox [3] (version 1.3) for SPM12 within 10 mm spheres around the individually determined peak activation in the bilateral occipital word form area (OWFA) and visual word form area (VWFA).

RESULTS

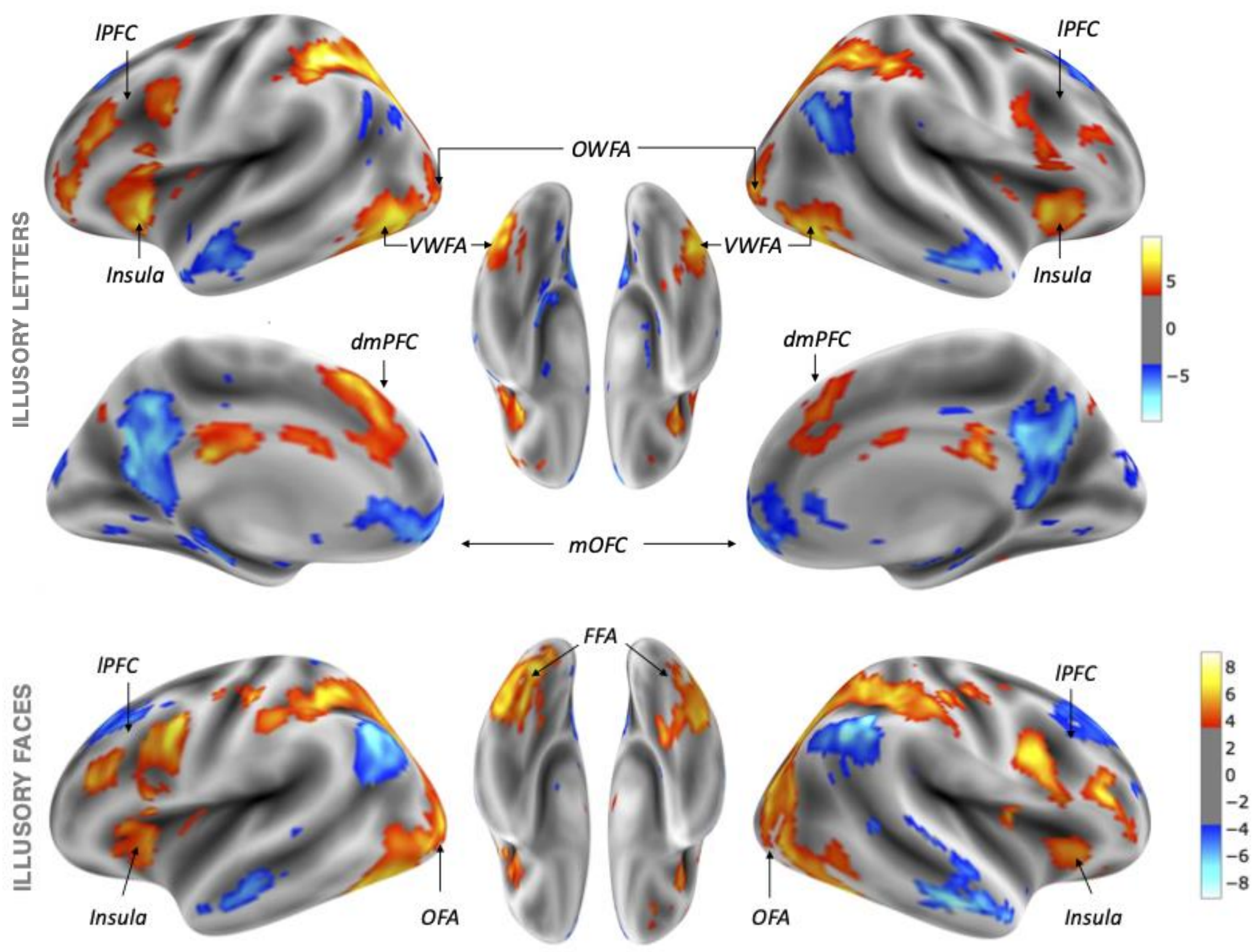

***Fig. 2 Top:** Brain activation associated with illusory letter detection (group analysis, contrast "letter vs. no-letter"). In the occipito-temporal cortex, the network includes several letter-sensitive regions, namely the VWFA and OWFA, along with their right-hemispheric homologues.*
***Bottom:** Brain activation associated with illusory face detection (group analysis, contrast "face vs. no-face"). In the occipito-temporal cortex, the network includes several face-sensitive regions, namely the occipital face area (OFA) and fusiform face area (FFA), along with their right-hemispheric homologues.*
***Top+Bottom:** In the prefrontal cortex, activation is observed in the lateral prefrontal cortex (lPFC), the insula, and the dorso-medial prefrontal cortex (dmPFC), whereas deactivation is found in the mOFC. Brain regions showing greater activity during the "letter detected"/"face detected" condition are highlighted in red-yellow ("activation"), while regions more active during the "no-letter detected"/"no-face detected" condition appear in blue-turquoise ("deactivation"). For illustrative purposes, the brain activation pattern is displayed at p < 0.001 (uncorrected). However, the main activation clusters were statistically significant at p < 0.05, FWE-corrected.*

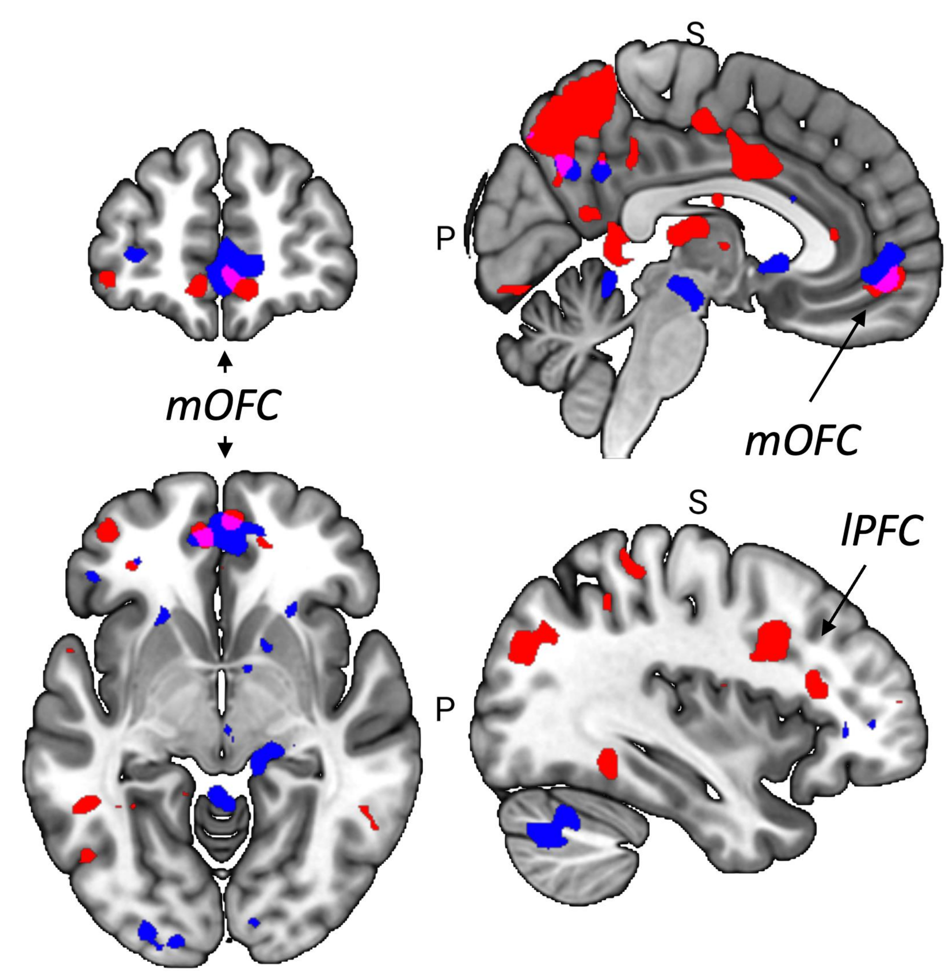

***Fig. 3 Blue:** We analysed the functional connectivity pattern (contrast „letter detected > no-letter detected") between the occipito-temporal and prefrontal cortex. We calculated separate PPI analyses for each activated brain region in the occipito-temporal cortex as seed region (i.e., left VWFA and OWFA and their right-hemispheric homologues). All PPI analyses revealed similar results. They showed interactions with a large network encompassing parietal, occipito-temporal and prefrontal brain regions. In the prefrontal cortex all four letter-sensitive brain areas were coupled with the mOFC. For illustrative purposes only the PPI pattern for the left VWFA seed is presented; p < 0.001 uncorrected.*
***Red:** During illusory face detection (contrast „face detected > no-face detected"), the bilateral OFA was significantly stronger connected to various brain regions, including bilateral OFC and lPFC. For illustrative purposes only the PPI pattern for the left OFA seed is presented; p < 0.001 uncorrected.*
***Pink:** Overlay of illusory letter PPI (lVWFA seed) and illusory face PPI (lOFA seed).*

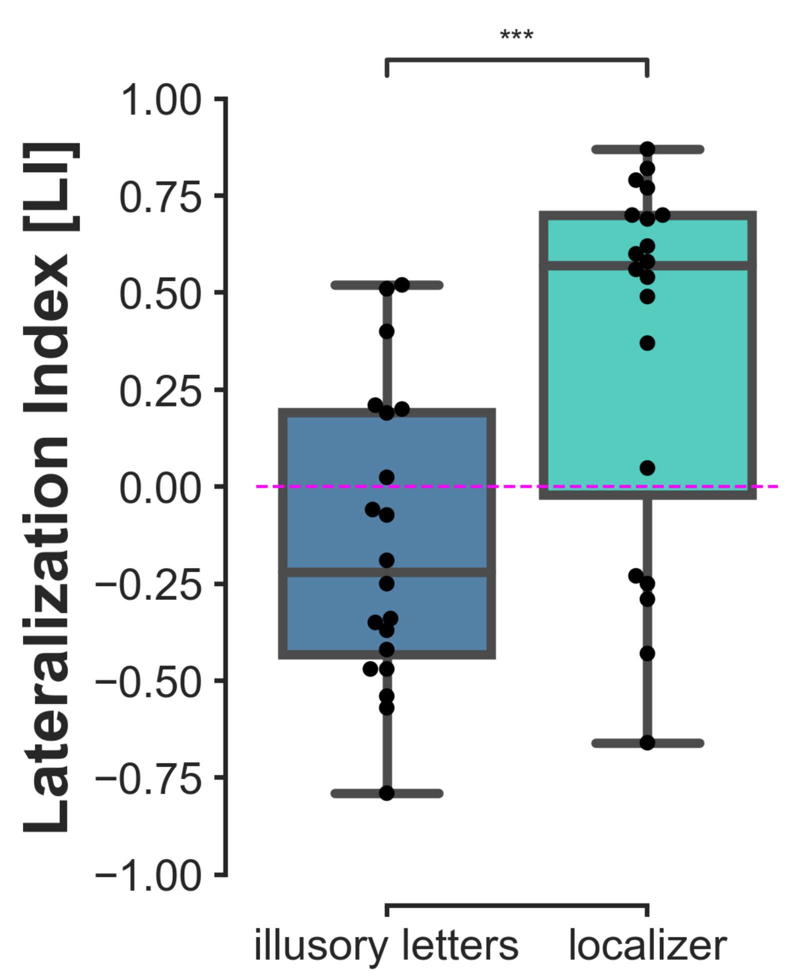

Fig. 4:** Hemispheric lateralization of brain activity in the VWFA for illusory letter detection (blue) and real letter perception (turquoise). Positive LI values indicate left-hemispheric dominance, while negative values indicate right-hemispheric dominance. As expected, the real letter localizer task elicited left-lateralized activity in the VWFA. In contrast, the illusory letter detection task resulted in a significant shift towards the right hemisphere (= p<0.001).*

CONCLUSION

As in the illusory face detection paradigm we also found activation in a network including occipito-temporal and prefrontal areas. The occipito-temporal regions corresponded with letter-responsive areas such as the VWFA and the OWFA. Prefrontal activation followed a similar pattern to that observed in illusory face detection.

REFERENCES

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