Comparison of functional activation in the temporal lobe of awake and anesthetized monkeys

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Introduction

Anesthesia is known to decrease the strength of fMRI responses in the cortex. The degree of loss of activation depends on the type of anesthesia, the depth of anesthesia and the area of the brain, and primary sensory areas are thought to be less affected than areas higher in the cortical pathway. Here we compared the fMRI responses of awake and anesthetized monkeys to the same movie stimulus at 7T. We are interested in fMRI of the visual ventral stream in awake monkeys; i.e. the areas from the occipital lobe to the inferior temporal cortex, because the ventral pathway is crucial for face and object recognition and memory.

Methods

Experiments were done on a vertical 7T Bruker Biospec in awake and anesthetized monkeys (*macaca mulatta*) weighing 8-15 kg, while the monkeys were viewing movies alternating with blank periods (trial-based design with 8s stimulus for awake monkeys, block design with 45s periods for anesthetized monkeys). The setup and methods for anesthetized and awake monkey fMRI have been described previously [1-4]. Anesthesia was a balanced remifentanyl/mivacurium regimen. For anesthetized monkeys a custom-designed quadrature volume coil was used. Multishot GE-EPI functional images were acquired with the slices oriented along the temporal lobe. The in-plane resolution was 1.5 mm for awake monkeys and 0.75 mm for anesthetized monkeys, with a slice thickness of 2 mm. TE/TR was 19/1000 ms for awake monkeys and 20/750 ms for anesthetized monkeys

Results

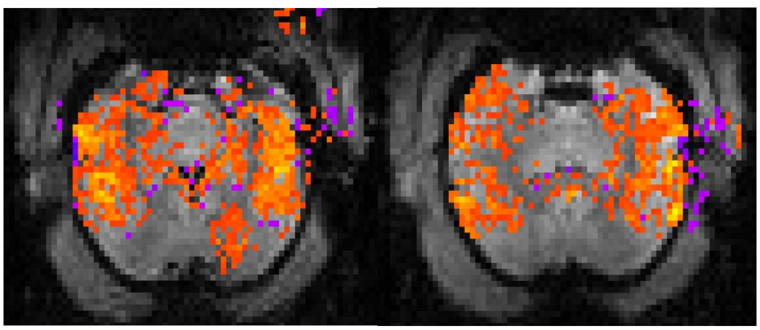

Figure 1: awake monkey (B04)

Figure 1 shows activation maps of two slices in the awake monkey reflecting the contrast movie > blank at approximately the level of the temporal sulcus and just below it. The figure shows extensive functional activation in STS and anterior temporal lobe. The activation patterns match the known visual areas in the macaque based on electrophysiology [5,6].

Figure 2 shows the functional map obtained under anesthesia in approximately the same slices (individual differences in anatomy between monkeys can result in minor differences in slice angle). The figure shows extensive and robust functional activity in early visual areas and STS, but also in anterior TE. Activation in anesthetized monkeys was robust, and monkeys that showed V1 activation consistently also showed anterior temporal lobe activation. The areas that are activated under anesthesia are similar to the areas that are active in the awake monkey. Most areas that are activated in the awake monkey are activated in anesthetized monkeys also. The most striking difference is the presence of negative BOLD signals in the anesthetized monkey indicated by purple colors. Other differences are the more sparse locations of activation in the anesthetized monkey, which may be due to lower BOLD signal intensity or due to reduced partial volume effects at higher resolution.

Conclusion

We find extensive activation of the ventral visual pathway under anesthesia, and large similarities between the activation maps recorded in awake and anesthetized monkeys, including areas high in the visual pathway like anterior TE. Although functional activation under anesthesia is usually weaker than in the awake animal, the high SNR and higher BOLD signal at 7T and the anesthesia protocol allow us to also capture activity also in higher cortical areas.

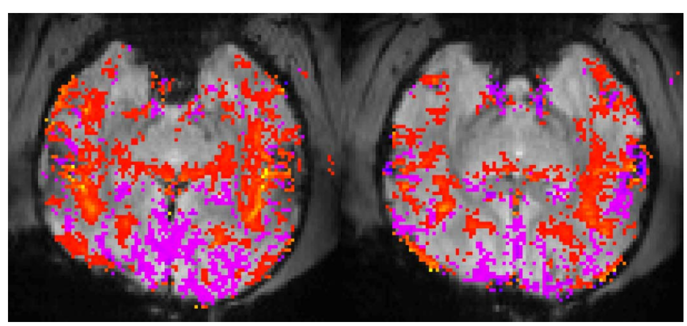

Figure 2: anesthetized monkey (B07)

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References

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