Spin versus gradient echo sequence: what is better for pain research with small animal fMRI?

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Introduction

Functional MRI based on blood oxygenation level-dependent (BOLD) contrast has become the most commonly used methodology for mapping the human brain. The majority of studies are using gradient-echo (GE) sequences. The functional contrast obtained with SE-based fMRI differs from GE-based fMRI. In an SE experiment, static dephasing effects that contribute to the BOLD signal are refocused. This results in reduced functional signal by a factor of 2–4, depending on the underlying vascular architecture (2,3,4). The aim of this study was to compare these two approaches for the purposes of pain research in anesthetized rats. According to our experience, certain parameters of BOLD activity are more relevant for measuring brain responses to pain and estimation of analgesic drugs efficiency, then the other ones. Bold signal amplitude appears to us as the most important parameter (1).

Materials and Methods

FMRI experiments were performed on a 4.7 T BRUKER Biospec scanner with a free bore of 40 cm, equipped with an actively RF-decoupled coil system on a Wistar male rats weighing ca. 350 g. The contact heat stimulation was performed using the custom made computer controlled Peltier heating and cooling device (MRI-ThS1-2ch). Two Peltier elements with 15x15 mm surface were fixed at the both hindpaws. Starting at a baseline of 34°C the stimulation temperature of 50°C was used. A whole-body birdcage resonator enabled homogenous excitation, and a 3 cm surface coil array (4 channels), located directly above the head of the animal to maximize the signal to- noise-ratio, was used as a receiver coil. The scanning procedure started with the acquisition of T2 weighted spin echo horizontal anatomical reference images (slice thickness 1 mm, field of view 35 x35 mm, matrix 256 x128, TR = 2800 ms, TEef = 77 ms) using a rapid acquisition relaxation enhanced sequence (RARE, Henning et al., 1986). Functional images were acquired using Echo Planar Technique (EPI). First, a set of 300 axial single slice scans with a high time resolution (200 ms per scan) was acquired (slice thickness 1 mm, field of view 25x25 mm, matrix 64x64, TR = 200 ms, TEef = 23.4 ms). The resulting set was evaluated visually. In case of visible motion artifacts, the animal was remounted. Afterwards a functional series of 3000 sets of eleven axial GE EPI images (slice thickness 1 mm, field of view 25 x25 mm, matrix 64x64, TR = 1000 ms, TEef = 23.4 ms) was acquired. The measurement was repeated with SE EPI, with the same parameters but Teff = 64ms. During EPI experiments heat stimulus was used during 20 seconds and regularly repeated after 220 sec alternatively on left and right forepaw. Functional analysis was performed using BrainVoyager and home written IDL program.

Results and Discussion

To compare these two different approaches we have chosen 4 different parameters of the BOLD response. According to our experiences (1) these are most representative for characterisation of pain response of the rat brain; “blobsize” - activated volume, “peakheight” – maximum BOLD signal amplitude, “peaktime” – delay between start of BOLD response to time of maximal response, “probability” – probability of activation. Figure 1 clearly demonstrated that activated volume depicted by GE was 3-4 times larger than by SE. Figure 2 demonstrates higher activation probability in GE measurements compare to SE. Both these facts are consistent with other studies. In contrast to these we found that the average maximal amplitude of BOLD signal detected by SE was higher than the one detected by GE averaged over the brain structures activated (Figure 3). This is contraintuitive with respect to results from Fig.1 and Fig 2. and findings of previous studies. These studies were dealing mostly with awake humans and different experimental paradigms, contrary our experiments were performed in anesthetized rats. With respect to peaktime (Fig. 4), we did not find any significant difference between these approaches, which also does not correspond to other findings (3).

Conclusion

According to our experience (1), BOLD signal amplitude appears to be the most relevant parameter to estimate brain responses to pain and the efficiency of analgesic drugs. Since SE is capable of reflecting this parameter better in more restricted brain areas than GE, therefore, we suggest to use SE more extensively in pain research for characterizing analgesic effects. This might compensate for the other known disadvantages of SE, like smaller detectable cluster size and lower probability.

References

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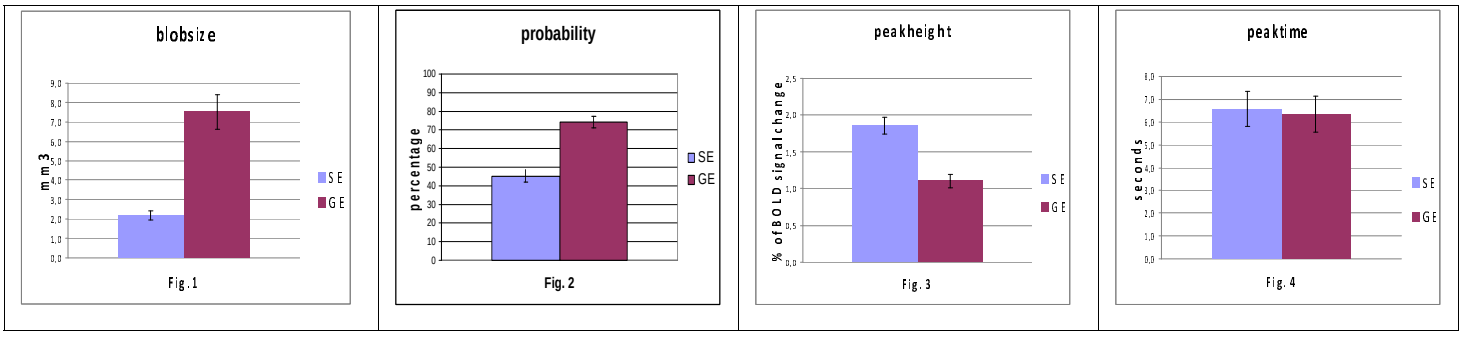

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