Multi-echo BOLD Index: Figuring out false positive and providing detailed activation patterns in task fMRI

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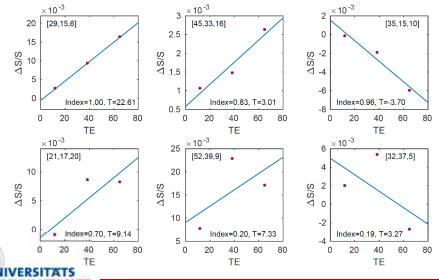
Introduction

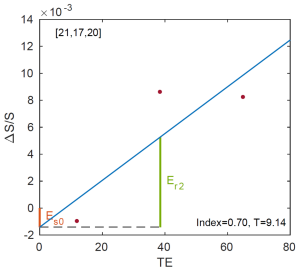
It is clear that fMRI is quite successful in brain activation region locating and brain functional disease during the last past nearly 30 years. However, the false-positive and activation boundary puzzled the scientists in our field quite a lot. In 2009, Bennett showed in his famous dead fish experiment that the dead salmon's brain even became active during photostimulation with standard fMRI analysis. How to judge whether the voxel is active? For the standard t-test analysis, people can use p<0.01 statistics and also p<0.05 statistics, the defined regions are different. Which is the right activation boundary? For the t-test analysis, do the higher T-value regions mean the stronger response regions?

In this poster, we show how we try to answer the false-positive, activation boundary problem and figure our activation patterns from the aspect of a multi-echo BOLD Index in a glimpse.

Methods

- 16 healthy volunteers, visual and finger tapping task (BLOCK design)
- TR=550ms, TE=[12.00, 38.52, 65.04]ms, voxel size=3*3*4 mm^3.
- 2 high resolution volunteers, same task
- TR=1410ms, TE=[14.0, 40.36, 66.72]ms, voxel size=2*2*3mm^3.





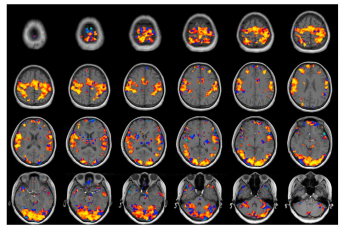
$$\frac{\Delta S}{S} = \frac{\Delta S_0}{S_0} - \mathrm{TE} \cdot \Delta R_2^*$$

$$BOLD\ Index = \frac{1}{e^{\frac{E_{S0}+res-E_{T2}}{res}} + 1}$$

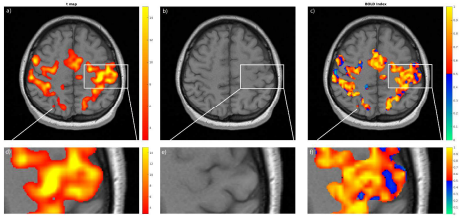
Non-BOLD signal: E_{s0} + res
BOLD signal: E_{T2}

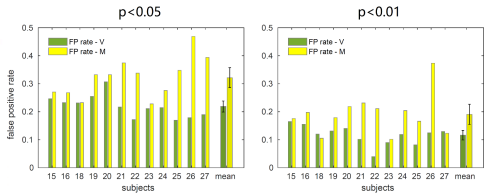
Results

p<0.05



Finger tapping activation patterns





False Positive ratio	Visual	Motor
p<0.05	21.9%	32.2%
p<0.01	11.6%	19.0%

Discussion

- Multi-echo BOLD Index provided a method to estimate whether the signal is BOLD or non-BOLD. With this Index, we found that there are about 20% false positive in classical T-test analysis results. Increasing of threshold will make the false positive ratio smaller.
- As the T-test marks the higher points on the region where it is not inside the brain cortex. The BOLD index could give detailed brain activation pattern, which was also achieved by Huber on 7T scanner(Huber et al.,2015).