

# Detection of the Negative Early Response in fMRI using Model-Free Neural Network Analysis

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## Introduction

Recent fMRI studies have revealed a negative early response in T2\*-weighted MR images [1-3] that is concordant with optical imaging studies [4-5]. One potential concern with the fMRI study is the use of a "dip" model in the correlation analysis of individual subject data, which makes the result somewhat subjective. In this work, a model free approach is used to investigate the presence of the early response in fMRI data. The analysis is based on a self organizing map (SOM) neural network [6] that was previously applied to fMRI data analysis [7]. The advantage of the SOM network is that it generates nodes corresponding to clusters in the data and, furthermore, it provides a 2-dimensional map of the nodes based on their similarity. The latter property allows interactive grouping of clusters based on the map. Our application of the SOM network to fMRI data acquired with high temporal resolution indicates that the early response is present in the data and its detection does not rely on the use of dip model.

## Methods

### MRI

Data were obtained in 3 normal volunteers on a 4T whole MR scanner. In each experimental fMRI run, 550 T2\*-weighted images were collected using a single-shot EPI sequence (TR/TE: 0.3s/30msec, 64x64, FOV: 20x20 cm<sup>2</sup>, 5 mm sagittal slice). Neuronal stimulation paradigm consists of three 45-second epochs each having a 3.6s visual stimulus (light emitting goggles flashing at 8 Hz). Physiological activity was concurrently monitored using a respiratory pressure belt and a pulse oximeter wrapped around the volunteer's finger. The acquired MR data were first processed to remove physiological fluctuations as previously described [7], and the 3 epochs in each run were averaged to generate a single run for subsequent analysis.

### Neural Network

The Self-Organizing Map was configured on a two-dimensional lattice. Each node in the lattice corresponds to a time course pattern. In training the map, each pixel is mapped to the node in the network that best fits its time course. Once the best match is determined for this pixel, the patterns of the matched node and its neighbors are updated based on a kernel function, which depends on both the training time and the distance to the matched node. The function we used is that given by Kohonen [3]:

$$h_{ij} = h_0 \exp(-|r_i - r_c|^2 / \sigma^2),$$

where  $\sigma$  is independent of training time  $t$  and

$$h_0 = \exp(-t/t_0)$$

is a monotonically decreasing function with respect to training time  $t$ . The two parameters in the kernel function,  $\sigma$  and  $t_0$ , determine the neighborhood influence and the training speed of the neural network. After a number of test runs, it was found that the following values:

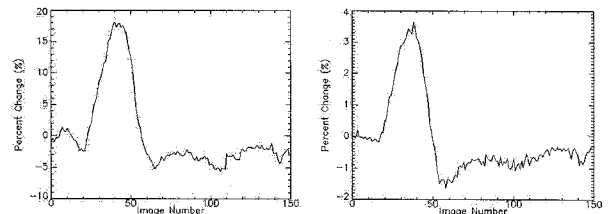
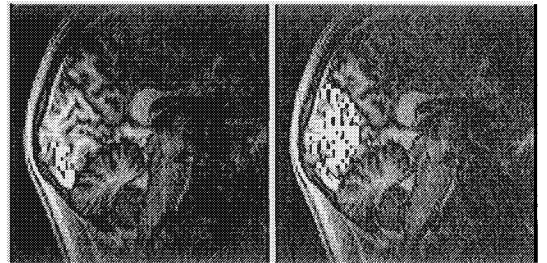
$$t_0 = 100, \sigma = 1$$

were most appropriate for the fMRI data considered. The neural network was initialized as a naïve network for training number 0. The data from the region of interest

were then fed into the neural network. The neural network was trained with the data set over 200 times.

## Results

At the end of the training, a number of distinct pixel patterns were observed. The nodes that fit into patterns of interest were grouped and analyzed. There were a number of pixels exhibiting the negative early response prior to the subsequent positive response. The delayed response was present more globally while the negative early response was much more localized (see figures below).



The image on the left shows the pixels exhibiting the early negative response preceding the delayed response, and the image on the right shows those pixels that demonstrated only the delayed response. Their respective average time courses are displayed beneath. The visual stimulation starts at image 10.

## Conclusion

The negative early response in fMRI data can be detected with a model-free analysis, indicating that it is inherent in the MRI data. The spatial pattern of the early response detected with the neural network approach is similar to that obtained with the "dip" model correlation analysis [2]. Our results also indicate that neural network analysis can be applied for detecting unknown activation patterns.

## References

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