High resolution fcMRI: Degrees of correlation within the rat brain finger representation

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INTRODUCTION

The somatosensory cortical representations of the individual digits of the rat can be distinguished using functional magnetic resonance imaging (fMRI) methods (1). Electrophysiological studies show that the representations for the rat forepaw are part of the barrel field. Well defined barrels that represent the distal phalanx and middle phalanx of each rat digit can be distinguished (2). In this study, we probe the limits of spatial resolution using resting-state functional connectivity MRI (fcMRI) methods and test the hypothesis that resolution as high as a single cortical column is possible. The rat digit cortex serves as a model system for basic biophysical investigations of fcMRI mechanisms.

METHODS

Six Sprague-Dawley rats were used in the study. Data were acquired with a Bruker AVANCE 9.4T animal scanner. The fMRI methods of Ref. 1 were used to define the brain somatosensory representations of the individual rat digits. Two resting-state fcMRI datasets were acquired for each rat prior to fMRI electrical stimulation acquisition to avoid bias. The method of analysis is described in Ref. 3. Briefly, for each digit region as defined by fMRI, the pixel time courses were filtered with a 0.1 Hz low-pass filter. Principal component analysis was carried out for the representation of each digit of each rat for each acquisition. Components were ranked by energy content and the first two components combined to form regional-specific time courses. Regional pairwise correlation coefficients (RPCC) for all eight digit regions were obtained for every acquisition. Data for each digit were averaged across all rats and acquisitions, and the average RPCC matrix formed.

RESULTS

Figure 1 shows the resulting RPCC matrices. Connectivities between adjacent digits and between right and left hemisphere representations of mirrored digits were found to be very strong. Patterns of connectivities within and across hemispheres were similar.

DISCUSSION

It can be presumed that all parts of the forepaw are connected within and across hemispheres. Data presented here show that some parts of the forepaw are more strongly connected than others, allowing the introduction of the concept of "degrees of connectivities" within functionally defined brain systems. This information does not seem to be obtainable using fMRI. The work of Waters et al. (2) shows that digits 2 and 5 are represented by two cortical layer 4 barrels, and digits 3 and 4 by three barrels. It is concluded that fMRI and fcMRI experiments involving single barrels appear to be within reach.

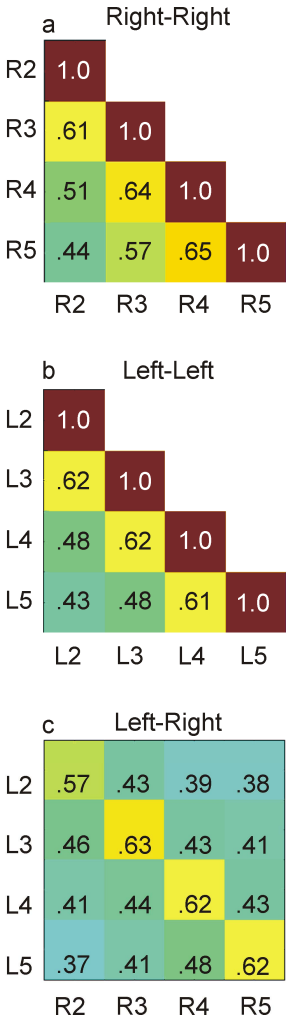

Fig. 1. RPCC matrices.

REFERENCES

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