Anterior-Posterior Dissociation of the Default Mode Network in Dogs

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Introduction

Many people have observed the Default mode network (DMN) in humans using seed-based and Independent Component Analysis (ICA)[1]. It has also been observed in monkeys [2]. In rodents, resting networks have been observed but not the DMN [3]. Dogs are higher mammals than rodents, but cognitively not as advanced as monkeys and humans. Therefore, they are an interesting species in the evolutionary hierarchy for probing the existence of DMN. In this study, we sought to know whether DMN and its functions, such as consciousness and self-referential processing, are exclusive in humans/monkey or do we also observe in animals like dogs, which have adapted so well in the human society. In order to address this issue, the resting state functional MRI data from the brains of lightly sedated dogs was acquired and Group ICA was performed for identifying the DMN.

Method

T2*-weighted functional images were acquired using a single-shot gradient-recalled echo planar imaging (EPI) sequence for BOLD contrast on a Siemens 3T scanner using a human knee coil. 17 axial slices of 3mm thickness, were acquired using the following parameters: TR=1000 ms (1510 ms in 2 dogs), TE=29 ms, FOV= 220mm, FA=90°, in-plane resolution 3×3 mm^2, and in-plane matrix 64×64. A total of 11 dogs were imaged and each dog completed 2 runs in a single scan session. Dogs were sedated with xylazine (1.1 mg/kg) and lightly anesthetized with ketamine HCL (5.5mg/kg). The anatomical images were acquired with MPRAGE for overlay and localization. The functional MRI data obtained from each of the anesthetized dogs was realigned by taking first image as the reference for all other scans using the least squares approach and a 6 parameter (rigid body) spatial transformation to do motion correction. Then the images were resliced and normalized to the anatomical of one of the dogs and spatially smoothed with a Gaussian filter with 4mm FWHM using SPM [4]. To remove any linear drift (or higher order drift) and offset from the signal, detrending followed by band pass filtering between frequencies 0.01 Hz to 0.1 Hz was performed using DPARSF [5]. Since standard brain masks for dogs are not available, a mask was created using Brain Suite [6]. Using GIFT software [7], group ICA was done using the following steps: (1) PCA (Principal component analysis) was done to reduce the size of the subject's functional data, (2) Independent components were determined using INFOMAX [8] algorithm, (3) Individual subject components were computed using the back reconstruction step and (4) The components were scaled to Z-scores to remove the arbitrary units of spatial maps and time courses during back reconstruction step. Finally, the mean, standard deviation and T maps were calculated for the group.

Results and Discussion

Spatial maps of components (Fig.1) showed that, unlike in humans and monkeys, dogs have localized networks in the anterior and posterior parts. In humans and monkeys, the anterior and posterior parts would be correlated, forming one distributed network which is known as DMN. On the other hand, in dogs, the anterior and posterior parts of the DMN seem to be dissociated. Previous works on humans [9] have shown that the organization of multiple functional resting networks shifts from a "local" anatomical emphasis in children to a more "distributed" architecture in young adults. Since human development mimics the evolutionary hierarchy, there is reason to believe that dogs represent the part of evolution where DMN is localized (as opposed to rodents which do not show a DMN), which then becomes more distributed in humans and monkeys.

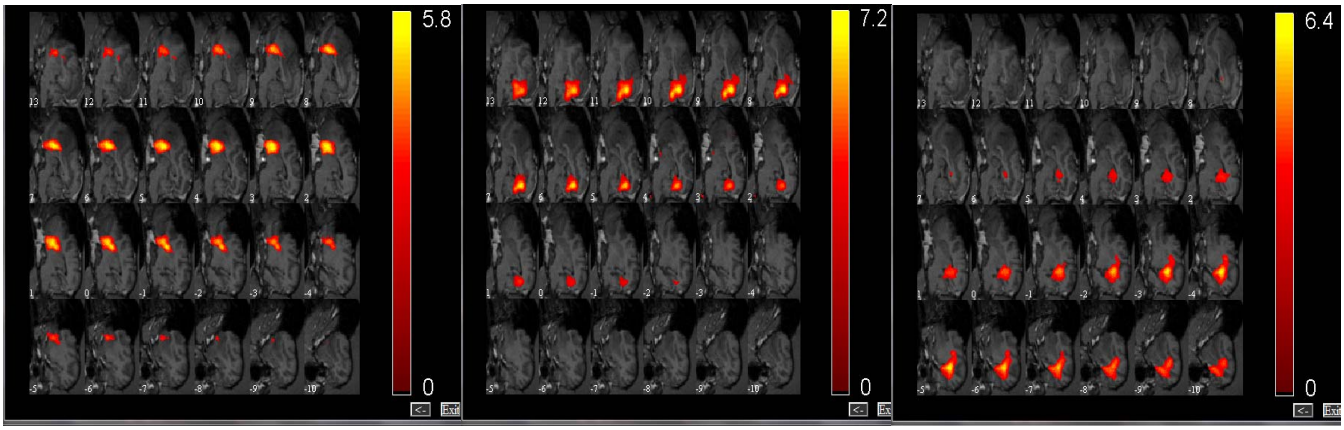

Fig.1 Spatial maps of components 5 (left), 3 (middle) and 20 (right). Note that the anterior (left) and posterior (middle, right) regions are dissociated

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