Development of the relationship between the Default Mode Network and frontal task-positive areas in preterm newborns: a RS-fMRI study.

Elisa Marchetta[1,2], Sara Cirillo[1], Pasquale Della Rosa[3], Silvia Pontesilli[1], Andrea Falini[1,4], Graziano Barera[5], Cristina Baldoli[1,4], and Paola Scifo[6,7]

[1]Neuroradiology Dept., San Raffaele Hospital, Milan, -, Italy, [2]University of Milano-Bicocca, Milan, -, Italy, [3]Institute of Molecular Bioimaging and Physiology, CNR, Segrate, -, Italy, [4]Vita-Salute San Raffaele University, Milan, -, Italy, [5]Division of Neonatology, Pediatrics Dept, San Raffaele Hospital, Milan, -, Italy, [6]Nuclear Medicine Dept., San Raffaele Hospital, Milan, -, Italy, [7]CERMAC, San Raffaele Hospital, Milan, -, Italy

Purpose

Resting state (RS) functional MRI is contributing to improve knowledge about human brain architecture and development in infants[1]. Aim of this study is to investigate the development with age of Default Mode Network (DMN) and its correlation with frontal task-positive areas in healthy preterm born infants by means of RS-fMRI.

Materials and methods

14 preterm-born infants without brain abnormalities visible in conventional MRI were studied in their first weeks of life (at birth: median PMA=31^{+6} weeks, range=27^{+4}–36^{+5}; at MRI exam: median=35^{+3} wPMA, range=33-38). All acquisitions were conducted on a 1.5 Tesla scanner (Philips Intera) in a warm, quiet and dark environment, during a spontaneous sleep without sedation. The MRI protocol consisted in: a) anatomical sequences for clinical assessment of newborns; b) RS-fMRI (EPI, TR=2500 ms; TE=29 ms; FOV= 180x180, voxel size= 2.25x2.25x3), 2 sessions of 70 volumes. FMRI data were pre-processed by using SPM8: 1) realignment of images to the mean of the functional scans; 2) coregistration of the T2 images on the mean image of fMRI; 3) normalization to a T2 template[2] of the corresponding mean age (35wPMA); 4) spatial smoothing (FWHM=6mm); 5) segmentation of the normalized T2 using probability maps[2] of the corresponding template (age 35 wPMA). Functional connectivity analysis was performed using REST toolbox[3]: i) linear regression of global, WM, CSF signals and movement parameters for noise correction[4]; ii) detrend and band-pass filtering (0.01-0.08 Hz); iii) Pearson's correlation at voxel level. For correlation analysis, 2 spherical ROIs (radius=5mm) were located as seeds for the two sub-networks of the DMN: the right and left medial prefrontal cortices (mPFC) for the anterior DMN, the posterior cingulated cortex (pCC) for the posterior DMN. Fisher's Z transform was applied to the correlation maps and the group effect was obtained with one-sample t-test (FWE $p<0.05$). Signals from the seeds and frontal task-positive regions[5,6] (dorsolateral prefrontal cortex and frontopolar areas, fig.1) were extracted and cross-correlated (r-coeff). Finally, the group significance of r-coeff and the correlation within the group of r-coeff and age at MRI scan were assessed by means of two tails t-tests (α=0.05).

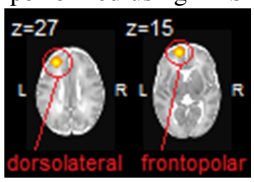

Fig.1: Seeds of dorsolateral and frontopolar areas

Results

Fig.2 shows group correlation maps of DMN. For anterior DMN (fig.2a) significant correlations were found between contiguous regions close to the seeds, while for posterior DMN (fig.2b) high correlations were also expanded towards lateral parietal areas, usually found in DMN in adults. Among the cross-correlations, only values of r-coeff between mPFCs and the left frontopolar were significant. In particular, left mPFC had a group correlation value r=0.53, with p=0.035 and t=2.339, similar values were found for the right mPFC (r=0.553, p=0.026, t=2.464). The t-test also revealed that (fig.3), in anterior DMN, the correlations between both mPFC and frontopolar area were significantly correlated with age (left mPFC: r=0.59, p=0.026; right mPFC: r=0.61, p=0.20).

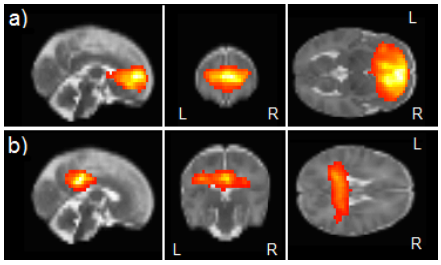

Fig. 2: Anterior (a) and posterior (b) DMN maps

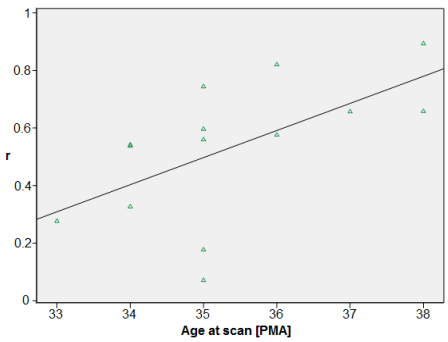

Fig. 3: Correlation with age of the functional connection between left mPFC and frontopolar.

Discussion and Conclusions

Correlation analysis describes the intrinsic association between brain areas belonging to functional networks. In this study, the cross analysis of correlation within DMN and its relation with age provided insights about the network modifications induced by maturation. Interestingly, we found positive correlations between mPFC and frontopolar region. Our data might suggest that the process of recruitment of frontal control areas start since prenatal period and very early age, although this region, related to high order functions, is characterized by a late myelination and its connectivity is known to develop further in time.

References

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