Prenatal Alcohol Exposure Alters Cortical Functioning in Sustained and Shifting Attention Tasks

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Introduction

Behavioral changes (including attention deficits) in individuals prenatally exposed to alcohol have been reported previously[1]. However, the neural basis underlying these behavioral alterations remains unclear. In this study, fMRI was used to investigate the cortical functioning of individuals with prenatal alcohol exposure (PAE) in sustained and shifting attention tasks. Two aspects of PAE-related changes were examined: (1) cortical networks involved in the two attention tasks, and (2) activation of regions in these networks. Results from this study can help us to understand how PAE affects human brain functions.

Methods

Recruited from a longitudinal cohort with documented exposure, three participant groups (control: 19, PAE/dysmorphic: 20, PAE/non-dysmorphic: 26) matched for ethnicity, age and education, participated in this study. The same block-design attention paradigm as previously reported[2] was used. In the sustained attention task, participants were required to respond to the circle (both circle and square shapes were presented randomly) while ignoring the stimulus color (red or green); in the shifting attention task, they were asked to respond to the circle (while ignoring the color) and to red (while ignoring the shape) alternately. For each participant, T_1-weighted images were obtained on a 3.0 Tesla Siemens Magnetom TRIO scanner with an MPRAGE sequence (TR=2600ms, TE=3.02ms, Flip Angle=8°, voxel size=1×1×1 mm^3). Functional images were collected with an EPI sequence (34 axial slices, slice thickness=3mm, slice gap=0mm, FOV=220mm^2, matrix=64×64, TE=32ms, TR=3000ms, flip angle=90°) when participants were performing the two attention tasks. FreeSurfer was used to reconstruct and register brain surface[3]. Surface-based fMRI analysis was carried out with AFNI[4]. After the behavioral performances were matched, data from 42 (14 for each group) and 45 (15 for each group) participants were analyzed for the sustained and shifting attention conditions.

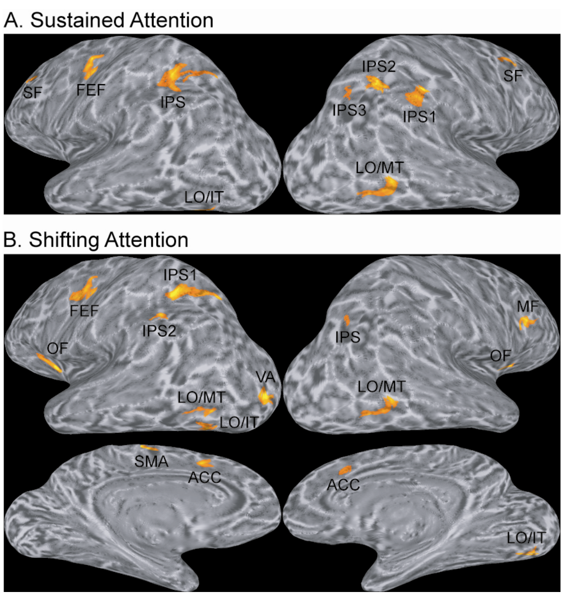

Figure 1. Cortical regions exhibiting different activations among the control, non-dysmorphic and dysmorphic groups in the sustained (A) and shifting (B) attention tasks.

Results

Activation maps for the three participant groups showed that similar cortical networks were involved in the sustained and shifting attention tasks across the groups. For each attention condition, the group maps were combined into a common activation map, and then group comparisons were performed within this common map. Cortical regions exhibiting group difference in activation are shown in Figure 1. For the sustained attention condition (Figure 1A), these regions included the IPS (intraparietal sulcus), FEF (frontal eye field), SF (superior frontal gyrus), LO/IT (lateral occipital/inferior temporal areas), and LO/MT (lateral occipital/middle temporal areas). More regions showed group difference in the shifting than in the sustained attention condition (Figure 1B), including the OF (orbital frontal gyrus), SMA (supplementary motor area) and ACC (anterior cingulate cortex). Further pair-wise comparisons among the three groups revealed that most of these regions showed stronger activation in the control than in the dysmorphic and/or non-dysmorphic group, except for the left SMA (non-dysmorphic > control and dysmorphic), left ACC (dysmorphic > control and non-dysmorphic) and right OF (dysmorphic > control and non-dysmorphic) in the shifting attention condition. Some of these regions also demonstrated different PAE effects (e.g., the left FEF in Figure 1, A and B: dysmorphic < control and non-dysmorphic; the right IPS1 and IPS3 in Figure 1A, the right IPS in Figure 1B: non-dysmorphic < control and dysmorphic).

Discussion and Conclusion

Our data suggest that the composition of the cortical attention network is not significantly changed by PAE. Instead, the neural activity of some critical regions in this network (FEF and IPS) is significantly reduced, resulting in more involvement of other regions when PAE individuals are performing a more difficult task. PAE individuals with or without external features may have different functional reorganization and compensation mechanisms. Further studies are required for understanding how the functional reorganization and compensation mechanisms work, and whether they also work for other cognitive functions.

Acknowledgements This work was supported by the NIH (R01 AA014373).

References

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