Parietal differences during nonsymbolic number comparison in children with prenatal alcohol exposure

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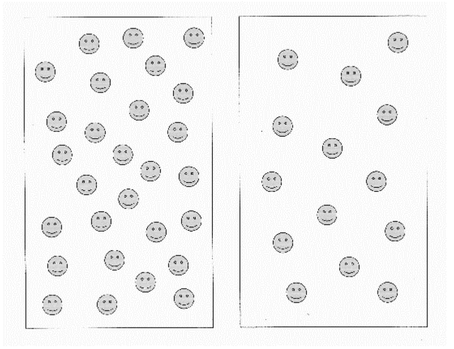
Introduction

Number processing is a cognitive domain particularly affected in fetal alcohol spectrum disorders [1,4,6]. Previous studies [e.g., 2] have identified 5 parietal regions critical to number processing: bilateral horizontal intraparietal sulcus (HIPS), bilateral posterior superior parietal lobule (PSPL), and left angular gyrus (AG). The HIPS is activated in tasks involving comparisons of relative quantities [3]; left AG, during verbal number manipulation [2]. PSPL supports attentional orienting. We investigated the effect of fetal alcohol exposure on brain activation in these regions during nonsymbolic number comparison.

Methods

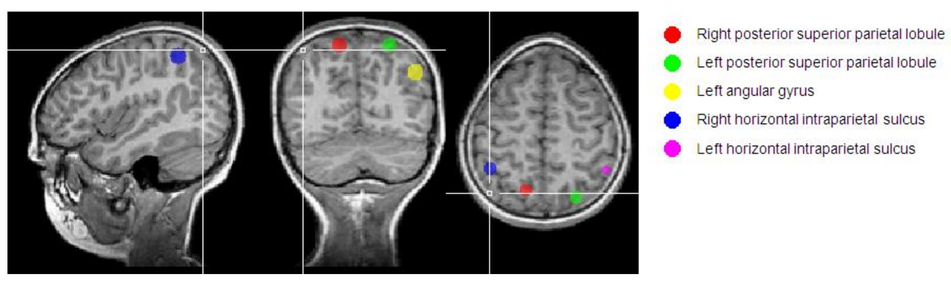
33 right-handed children (9.7-13.7 years; median=11.4) were scanned with a 3T Siemens Allegra scanner in Cape Town, South Africa. Fetal alcohol exposure was assessed by interviewing their mothers about their alcohol consumption during pregnancy using a timeline follow-back interview approach [5]. All children were assessed for fetal alcohol syndrome (FAS) diagnosis by expert dysmorpholgists at a community-based clinic conducted in 2005. 8 children were diagnosed with FAS or partial FAS (PFAS), 5 were nonsyndromal heavily exposed (HE), and 20 were controls whose mothers abstained or drank no more than minimally. FMRI data were acquired during nonsymbolic number comparison ("Which side has more faces?").

This task had 9 task blocks, each with 8 problems (16s), interleaved with 10s rest blocks. Each block was comprised of problems at 1 of 3 levels of difficulty, defined in terms of the ratio of number of faces on one side of the screen to the other (1:2, 2:3, 3:4).



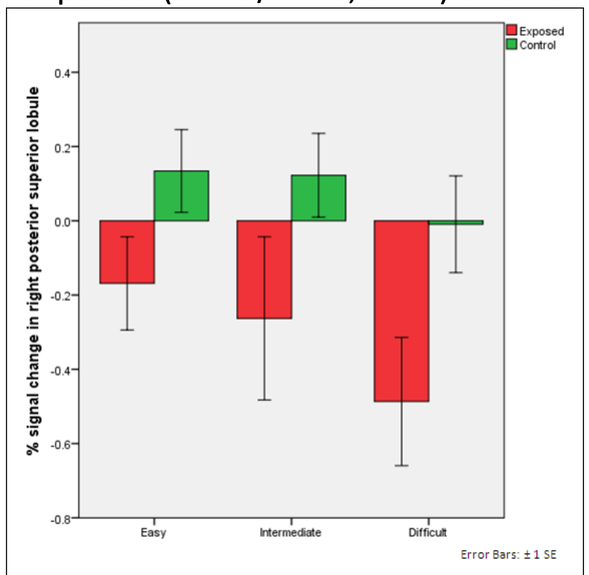
Stimuli were shown for only 1s to prevent counting. Blocks with <5 problems correct were modelled as bad blocks; functional data from children with ≥5 bad blocks were excluded (1 FAS, 2 control).

FMRI analyses were performed using BrainVoyager QX (Brain Innovation). Preprocessing included slice acquisition time and linear trend corrections, temporal smoothing, and motion correction. Data with motion >3mm translation, 3° rotation were excluded. Data from 1 control child was excluded from functional analysis due to excessive motion, as defined above. Additionally, 1 child with FAS and 1 control child were excluded for technical reasons. Regions of Interest (ROIs) were defined as spheres, radius 6mm around the centre coordinates of the 5 parietal regions [2]. Difficulty levels were weighted by the ratio of the number of faces on the two sides of the stimuli within each block to create a parametric model. Beta values estimated % signal change during the task, compared to rest, as well as the parametric increase in activation across difficulty levels.

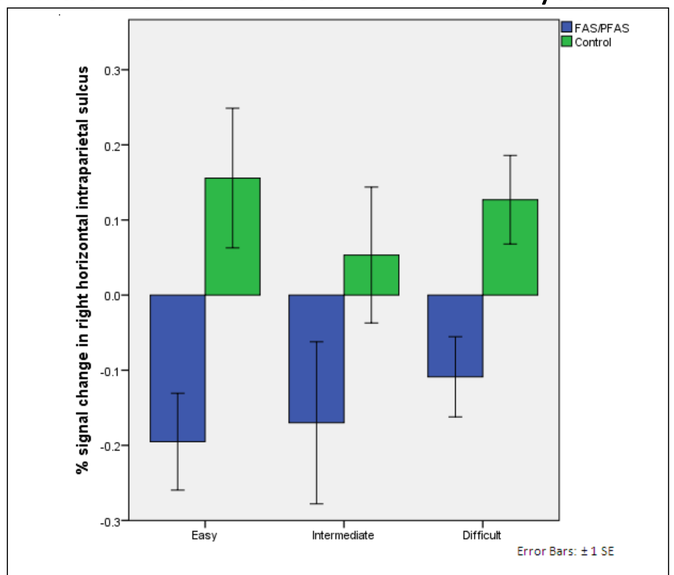


Results

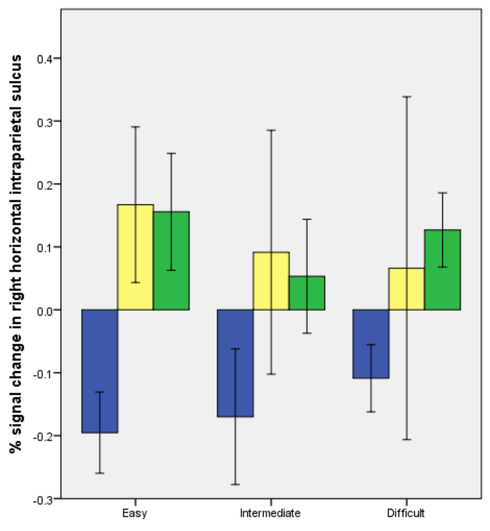
Behavioral data were analysed for 8 FAS/PFAS, 5 HE and 20 controls. Groups did not differ in accuracy or correct response reaction time. Data from 11 exposed (6 FAS/PFAS, 5 HE) and 16 controls were included in FMRI analyses.

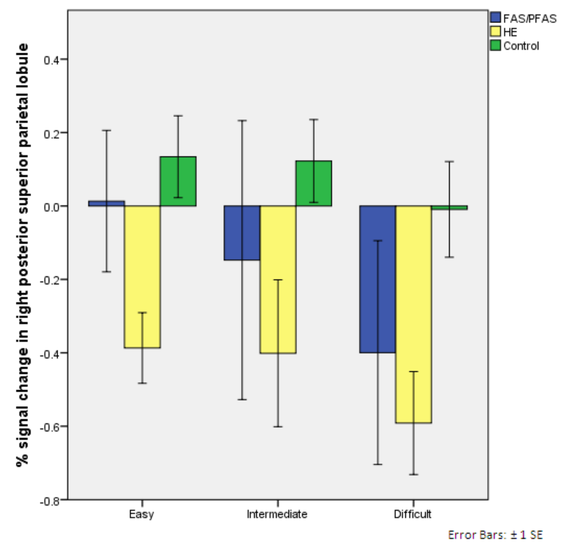


In the right PSPL, controls showed greater activation compared to exposed children, who showed deactivation in this region (p=0.04).



Although activation in the right HIPS did not differ between the exposed and control groups, the FAS/PFAS group did show less right HIPS activation than the controls (p=0.05).





Notably, when the FAS/PFAS and HE groups were separated, activation patterns in the right HIPS for the HE children were similar to those of the control children, while in the right PSPL they were similar to those in the FAS/PFAS group.

Relation of activation patterns to behavioral performance:

- Greater left PSPL activation was related to better task accuracy (r=0.46, p=0.02).
- With respect to task difficulty, the children who exhibited greater left PSPL activation with increasing task difficulty had shorter reaction times (r=-0.43, p=0.03).

Conclusions

- During this nonverbal numerical comparison task, the FAS/PFAS group showed less activation than controls in 2 parietal regions
  - Right HIPS, which mediates mental representation of relative quantities
  - Right PSPL, which supports attentional function during number processing
- In the nonsyndromal HE group
  - Right PSPL activation was also reduced when compared with controls
  - But the functioning of the right HIPS appeared to be spared
- The findings that greater left PSPL activation and greater increase in left PSPL activation with increased task difficulty were both associated with better task performance, provide additional evidence that this region supports attentional function during nonsymbolic number comparison.

References

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