False Belief and Intentions: Can the brain tell the difference?

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Introduction

The results from neuroimaging studies of Theory of Mind (ToM) are heterogeneous, implicating numerous brain regions, including the medial prefrontal cortex, temporo-parietal junction, and superior temporal regions. A recent review (Carrington & Bailey, 2009) concluded that although a clear confound, paradigmatic variation could not be accurately accounted for the variable imaging findings. Nevertheless, there was some evidence that false belief and deception might be associated with dissociable neural substrates. Reduced or spatially altered activity has been reported in several brain regions typically associated with ToM in individuals with ASD (e.g. Gilbert et al., 2009; Kana et al., 2009). Neuroimaging, within the context of neurodevelopmental disorders, has the potential to reveal some of these mechanisms, which to date have been not been investigated in ASD. Objectives: To determine whether the attribution of false beliefs (FB) and intentions (INT) was associated with dissociable patterns of brain activity in both typically developing (TD) individuals and individuals with an ASD.

Design/Methods

Participants: Unmedicated, right-handed, native English speaking males, aged between 14 and 45 years participated in this study. Participants fell into two groups: 20 individuals with an ASD and 23 individuals with no psychiatric diagnoses (TD) were recruited from the University of Oxford, FMRIB Centre; 4University of British Columbia. Paradigm: Participants were asked to select the appropriate ending to computationally constructed comic strip sequences consisting of three frames. Comic strips fell into four conditions: false belief (FB), intentions (INT), physical causality with characters (CP) and physical causality with objects (WAS).

Results

Participant demographics: The groups were matched for age (TD: 18±4.4; ASD: 22±7.4, 0.05, p=0.05) and sex (TD: 11; ASD: 11, 0.05, p=0.05). Two ROI (PCC/ventral cingulate) including 1-mm voxels were also matched for age, sex, height, and weight, and were included in the analysis. The ASD group included 20 males and 13 females, with a mean age of 21 years (range: 17–32 years). The TD group included 15 males and 5 females, with a mean age of 20 years (range: 16–25 years). There were no significant differences between the groups on any of these variables.

ROI: We focused on the medial prefrontal cortex (dmPFC) and the posterior cingulate cortex (PCC/ventral cingulate). The PCC/ventral cingulate is a key region of the ToM network, which is involved in the processing of false beliefs and deception. To examine these effects, we conducted a series of ROI analyses, comparing the ASD group to the TD group.

Discussion

The results from the ROI analyses are consistent with previous findings, showing evidence for reduced activity in the dmPFC and PCC/ventral cingulate in individuals with ASD. This suggests that individuals with ASD may have difficulties in attributing false beliefs and intentions. Future studies should explore the functional connectivity and structural integrity of these regions in individuals with ASD to better understand the neural mechanisms underlying these difficulties.

Limitations and future directions: The sample size was relatively small, and further studies with larger samples are needed to confirm these findings. Additionally, the results may be influenced by the use of a single-shot EPI sequence, which may have limitations in terms of spatial resolution and signal-to-noise ratio.

Conclusions

Consistent with previous neuroimaging studies, ToM was associated with activity in the dmPFC and PCC/ventral cingulate. This activity is known to be involved in the processing of false beliefs and deception. The results of the current study extend previous research by demonstrating that the PCC/ventral cingulate appears to be engaged during ToM reasoning tasks, regardless of the mental state, while the dmPFC is more selectively engaged for the attribution of False Belief.

The results were largely comparable in the TD and ASD groups, but exploration of the uncorrected data revealed subtle differences between groups in both candidate ToM regions. In the dmPFC, activity in the ASD group appeared to differentiate less between the FB and CO conditions, suggesting reduced specialization for the attribution of false belief. ROI analyses, however, indicated similar recruitment of the dmPFC by each condition in the two groups. There was a cluster of voxels in the PCC/ventral cingulate where activity in the ASD group differentiated between the INT and CP conditions significantly more than in the TD group. ROI analysis indicated that this effect could be due to greater activity in the INT condition rather than reduced activity in the CP condition (Fig. 5B), suggesting more efficient ToM processing during the attribution of intentions in the ASD group compared with TD. Note that group differences should be interpreted with caution as they were present in the uncorrected data only.