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(Article begins on next page)
MO 241
Varieties of intentions
Parametric activation of the anterior paracingulate cortex in theory of mind tasks
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Introduction
According to Theory of Mind (TOM), humans have a special ability to understand and interpret intentions of
other people also known as mindreading. Neuroimaging studies have shown the existence of a distributed neural
system underlying TOM (Gallagher et al. 2003). From these studies it has been concluded that a subregion of the
medial prefrontal cortex is specifically involved in the representation of mental states of others, namely the
anterior paracingulate cortex (PCC). However, the designs used in neuroimaging studies do not allow to
distinguish between representation of intentions of others acting in isolation (intention in action) and the
intentions of others involved in social interaction. Based on evolutionary considerations, we hypothesised that
anterior PCC activation is sensitive to the degree of social interaction in TOM task. Therefore, we predicted
anterior PCC to be activated parametrically in the following order: intentions in action in isolation < intentions for
future social interaction < intentions in actual social interaction.

Methods
12 (6 male, 6 female) healthy right-handed volunteers (age range: 19-27 years) were studied with fMRI. We used
cartoons involving a sequence of three pictures followed by a selection of three pictures of which the subjects had
to choose the correct ending of the cartoon. There were four conditions: (i) physical causality (only objects, no
persons, no intentions = control condition), (ii) intention in action (one person, simple intentions), (iii) intention
for future social interaction (one person intending to socially interact), (iv) intentions in social interaction (two
persons interacting with gestures). fMRI imaging: Magnetom Symphony (Siemens, Erlangen, Germany),
single-shot EPI-sequence, TE/TR 40/2250 ms, 25 slices. Image processing and data analysis: SPM99 (Wellcome
Institute of Cognitive Neurology, London). Results are from second level random effect analysis with p<0.001 on
the voxel and p<0.05 on the cluster level (both uncorrected).

Results
Behavioural results: No significant differences in accuracy and correctness. FMRI-results: Compared to the
control condition (i), typical TOM activation patterns (anterior PCC, anterior temporal pole and superior temporal
cortex) emerged only in condition (iii) and (iv). Anterior PCC showed the predicted pattern with no significant
activation for simple intentions in action, intermediate activation in the intentions for future social interaction
condition and strong activation in the actual social interaction condition.

Conclusion
Our data show that anterior PCC activation occurs only if the interpretation of cartoon stories is related to social
interaction (real or only implied) but not when simple intentions in action of isolated persons are represented. This
has implications for the design of TOM stories in future studies as well as for the characterisation of TOM
abilities in general.

References