Neural correlates of visuo-spatial perspective-taking and agency in a virtual ball-tossing game

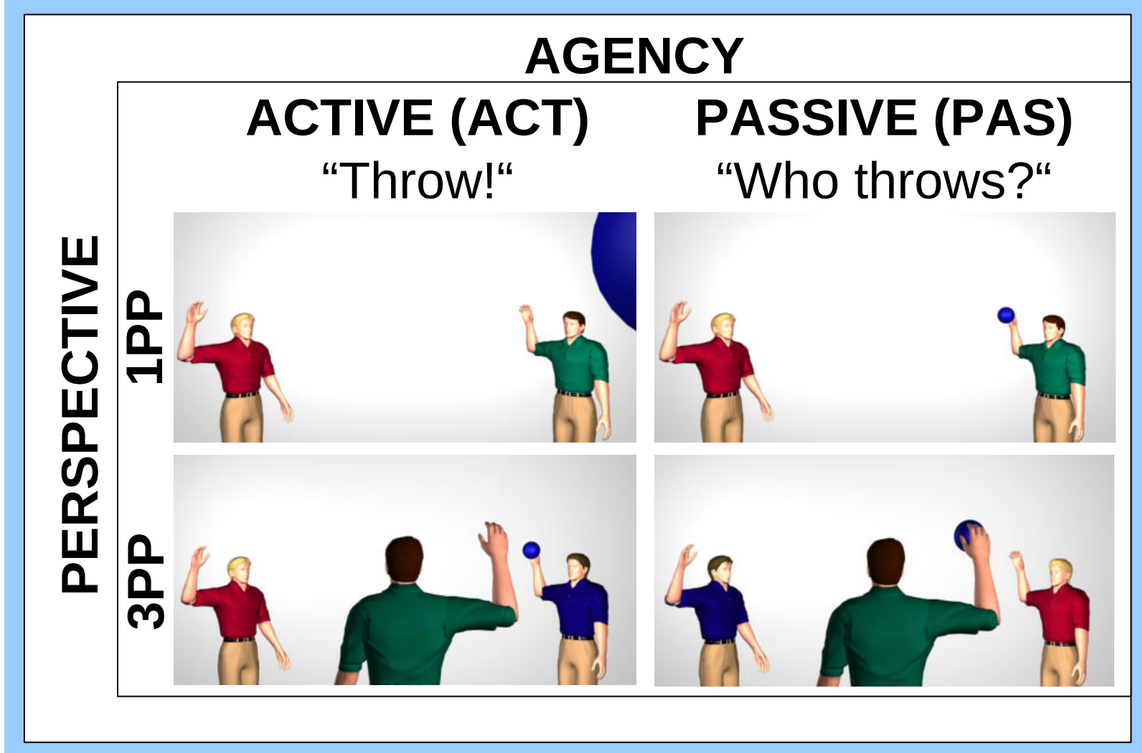
N. David[1,2], B. Bewernick[1], A. Newen[2], N. J. Shah[3], G. R. Fink[3,4], & K. Vogeley[3,5]

[1]Department of Psychiatry, University of Bonn; [2]Department of Philosophy, University of Tübingen; [3]Institute of Medicine, Research Center Jülich; [4]Department of Neurology, University of Aachen; [5]Department of Psychiatry, University of Cologne

Introduction

We investigated neural correlates of perspective-taking and agency, i.e. the sense of causing one's own actions, as two constituents of human self-consciousness in healthy subjects.[1] Perspective-taking and agency are crucial processes for the distinction of self and other. Disturbances of those contribute to key symptoms of schizophrenia where confusion about self and other occurs (e.g. deficits in mind-reading, delusions of control, thought insertion).[2,3] In the present study, we focus on visuo-spatial perspective-taking. We used dynamic, life-like stimuli that depicted a basic form of social interaction: playing a ball-tossing game with others. Investigating perspective-taking and agency in a two-factorial design allowed us to examine how neural correlates of agency and 1PP overlap or interact.

Study Design and Task



Task. Subjects interacted with two virtual characters (avatars) in a ball-tossing game. There were two tasks. During an active (ACT) task (see left column), subjects threw a ball to the red avatar by button-press. During a passive (PAS) task (right column), they had to press a button to indicate which of the avatars threw the ball. Both tasks were left/right-decision tasks, which had to be performed from either a first-person perspective (1PP) (row above), in which subjects interacted from their own perspective, or a third-person perspective (3PP). Here a third avatar (blue) was included in the game from whose perspective the subject also accomplished the tasks (see row below).

Figure 1. 2x2 design with the factors perspective and agency manipulated within a virtual ball-tossing game. Each factor comprised 2 levels: a first-person perspective (1PP) vs. a third-person perspective (3PP) for perspective, an active task (ACT) vs. a passive task (PAS) for agency. Instructions are given in quotes.

Behavioural Results

13 healthy males (age 25.2 ± 4.8 years)

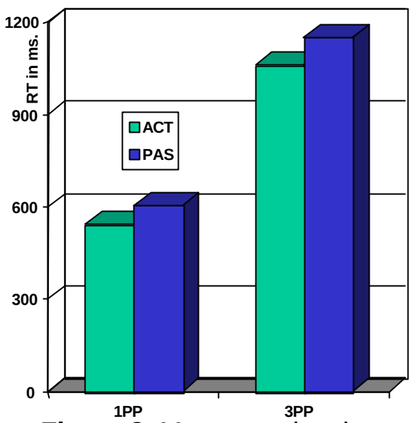


Figure 2. Mean reaction times (RT)

Significant main effects:
Subjects were faster in 1PP vs. 3PP (F1,12=302.87; p<.001) & faster in ACT vs. PAS (F1,12= 18.03; p<.005).

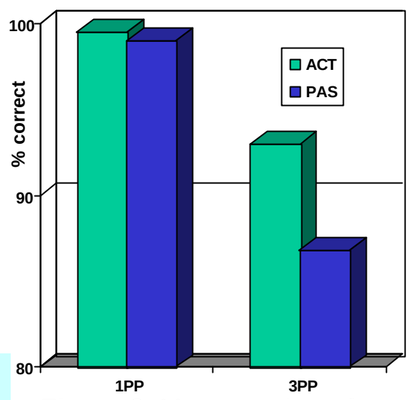


Figure 3. Mean number of correct answers (in %)

Significant interaction:
Subjects were less accurate in 3PP+PAS (F1,12= 8.69; p<.05).

fMRI data analysis

- n=13
- SPM2; random effects model; block design
- p<.05 2-tailed, corrected for multiple comparisons (FDR)
  (except for ACT: p>.0005 uncorrected)

fMRI Results

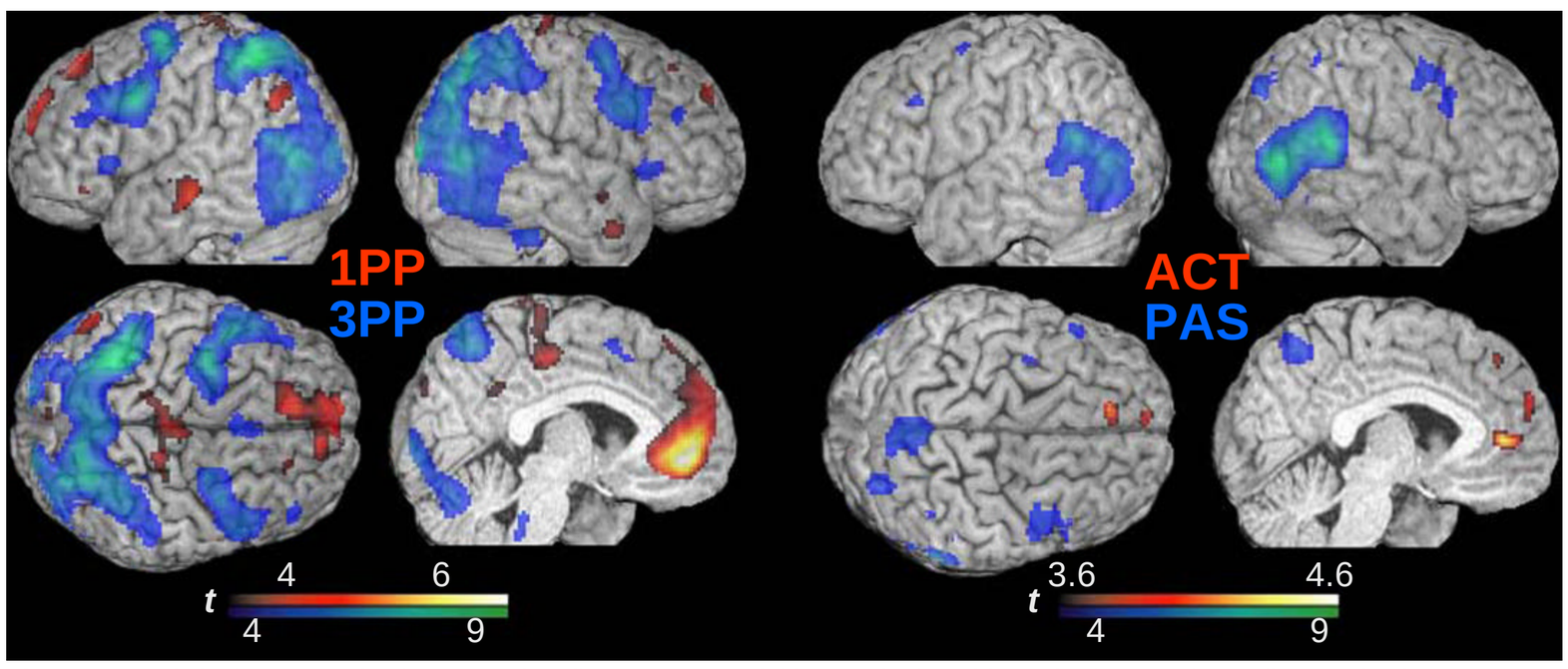


Figure 4. Statistical group-activation-maps for all contrasts overlaid on a single subject's brain. In red-to-yellow, activation greater during 1PP (1PP>3PP) and during ACT (ACT> PAS). In blue-to-green, activation greater during 3PP (3PP>1PP) and during PAS (PAS> ACT).

1PP: cortical midline structures, middle & superior temporal, inferior parietal, motor cortices (precentral & SMA), subcortical/ limbic regions (amygdala, hippocampus, putamen, insula, orbital)

3PP: inferior frontal, premotor, inferior & superior parietal, temporo-parietal, thalamus, insula, cerebellum & brainstem

ACT: no voxels after correcting for multiple comparisons. At p>.0005 uncorrected: cortical midline structures (MPFC & anterior cingulate), cerebellum

PAS: occipito-temporal cortices (e.g. posterior part of superior temporal sulcus, fusiform, extrastriate body area), temporo-parietal, inferior/ middle frontal, precentral/ premotor

Figure 2 demonstrates an overlap of activation between 1PP & ACT and 3PP & PAS. However, an interaction of the two factors, perspective & agency/task, with respect to their neural correlates did not reach significance!

Summary and Conclusions

1.We provide further evidence for a neural network concerned with representations of the self and other, with medial prefrontal regions associated with self-representations (1PP & being an agent) and posterior parietal & posterior temporal regions with the representation of others (3PP & watching others being agents).

2.In accordance with Decety and Sommerville (2003),[4] we propose that human self-consciousness is a construct that relies on a neural network concerned with self-other representations like the one detected in the present study.

3.Dysfunctions of these regions may account for disturbances of the self related to perspective-taking and agency as observed in patients with schizophrenia.

References: [1] Gallagher, S. *TiCS* (2000); [2] Frith, C.D.& Frith, U. *Science* (1999); [3] Franck, N. et al. *Am J Psychiatry* (2001); [4] Decety, J. & Sommerville, J.A. *TiCS* (2003).