NeuroImage 155 (2017) 305–311

Contents lists available at ScienceDirect

NeuroImage

journal homepage: www.elsevier.com/locate/neuroimage

Attentional processes, not implicit mentalizing, mediate performance in a perspective-taking task: Evidence from stimulation of the temporoparietal junction

Idalmis Santiesteban[a,*], Simran Kaur[b], Geoffrey Bird[c,d], Caroline Catmur[b,e,**]

[a] Department of Psychology, University of Cambridge, Downing Street, Cambridge CB2 3EB, UK
[b] School of Psychology, University of Surrey, Guildford, Surrey GU2 7XH, UK
[c] Department of Experimental Psychology, University of Oxford, 9 South Parks Rd, Oxford OX1 3UD, UK
[d] MRC Social, Genetic and Developmental Psychiatry Centre, Institute of Psychiatry, Kings College London, DeCrespigny Park, London SE5 8AF, UK
[e] Department of Psychology, Institute of Psychiatry, Psychology & Neuroscience, King's College London, London SE1 1UL, UK

ARTICLE INFO

Keywords:
Automatic attentional orienting
Attentional pop-out
Dot perspective-taking task
Implicit mentalizing
Perspective-taking
Sub-mentalizing
Temporoparietal junction
Repetitive transcranial magnetic stimulation

ABSTRACT

Mentalizing is a fundamental process underpinning human social interaction. Claims of the existence of 'implicit mentalizing' represent a fundamental shift in our understanding of this important skill, suggesting that preverbal infants and even animals may be capable of mentalizing. One of the most influential tasks supporting such claims in adults is the dot perspective-taking task, but demonstrations of similar performance on this task for mentalistic and non-mentalistic stimuli have led to the suggestion that this task in fact measures domain-general processes, rather than implicit mentalizing. A mentalizing explanation was supported by fMRI data claiming to show greater activation of brain areas involved in mentalizing, including right temporoparietal junction (rTPJ), when participants made self-perspective judgements in a mentalistic, but not in a non-mentalistic condition, an interpretation subsequently challenged. Here we provide the first causal test of the mentalizing claim using disruptive transcranial magnetic stimulation of rTPJ during self-perspective judgements. We found no evidence for a distinction between mentalistic and non-mentalistic stimuli: stimulation of rTPJ impaired performance on all self-perspective trials, regardless of the mentalistic/non-mentalistic nature of the stimulus. Our data support a domain-general attentional interpretation of performance on the dot perspective-taking task, a role which is subserved by the rTPJ.

Introduction

Mentalizing, the ability to attribute mental states to oneself and others, is a fundamental process underpinning human social interaction. Although generally assumed to be an explicit process, requiring conscious thought and cognitive flexibility, there have been recent claims that mentalizing can also be *implicit* - that it is a fast and efficient process that occurs automatically, without conscious awareness (Apperly, 2011; Apperly and Butterfill, 2009; Frith and Frith, 2012). Claims of implicit mentalizing represent a fundamental shift in our understanding of this important skill, with suggestions that it is present in pre-linguistic infants (Baillargeon et al., 2010; Onishi and Baillargeon, 2005) and in a variety of social animals (e.g. Premack and Woodruff, 1978; Call, 2012; Krupenye et al., 2016) – although, for contrasting views see De Bruin and Newen (2012), Heyes (2014a, 2014b, 2017), Penn and Povinelli (2007), Perner and Ruffman (2005), Phillips et al. (2015), and Ruffman et al., (2012).

Recent studies have spurred controversy by claiming that implicit mentalizing persists in adulthood. Evidence for this claim comes from visual perspective-taking studies using a paradigm known as the 'dot perspective-taking task' (henceforth 'the dots task'; e.g. Samson et al., 2010; McCleery et al., 2011; Qureshi et al., 2010).

In the dots task, participants are presented with a word cue indicating whether they will be required to adopt their own perspective ("YOU": 'self-perspective' trials) or someone else's ("SHE"/"HE": 'non-self-perspective' trials), before the appearance of a number cue (0–3), followed by a picture of a room containing large circles/dots pinned on the wall. In the centre of the room, there is a human-like figure or avatar facing either the left or right wall. The participant's task is to verify if the cued number corresponds to the number of dots that they

* Corresponding author.
** Corresponding author at: Department of Psychology, Institute of Psychiatry, Psychology & Neuroscience, King's College London, London, SE1 1UL, UK.
E-mail addresses: is405@cam.ac.uk (I. Santiesteban), caroline.catmur@kcl.ac.uk (C. Catmur).

http://dx.doi.org/10.1016/j.neuroimage.2017.04.055
Received 6 January 2017; Accepted 24 April 2017
Available online 25 April 2017

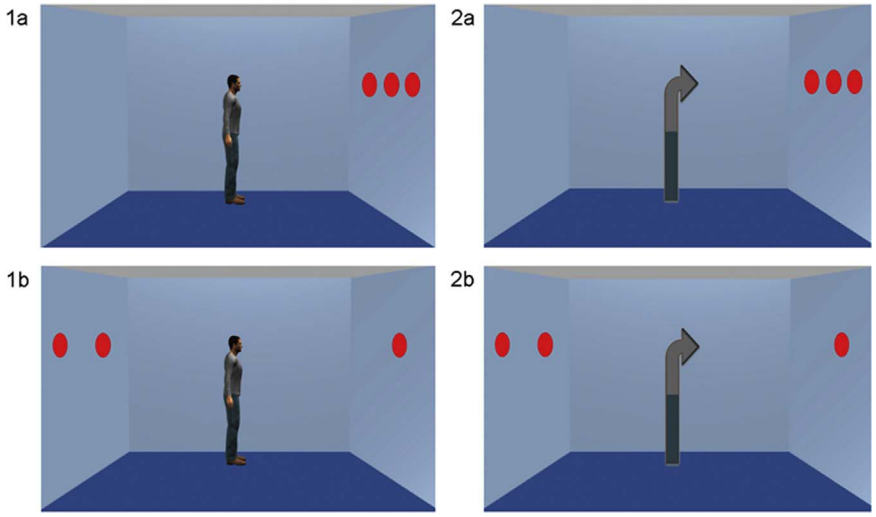

Fig. 1. Examples of the stimuli. The avatar and arrow trials were either consistent (1a, 2a) or inconsistent (1b, 2b) with the participant's perspective.

(self-perspective trials) or the avatar (non-self-perspective trials) can see. Depending on the location of the dots, sometimes the number of dots that can be seen is the same for both participant and avatar (consistent trials), whereas sometimes the number of dots is different across the two perspectives (inconsistent trials); see Fig. 1. A robust finding from all previous studies using this task is that participants' responses are slower in inconsistent compared to consistent trials. Furthermore, this effect is found even when participants make judgements on self-perspective trials and thus do not need to take into account the avatar's perspective. This 'self-consistency effect' has been interpreted as evidence of implicit mentalizing: participants automatically adopt the other person's perspective and seem unable to ignore it, even when they are only required to adopt their own perspective (Samson et al., 2010). However, the implicit mentalizing interpretation has been criticized because the task lacked a non-mentalistic control condition. When such controls are included (e.g. Cole et al., 2016; Conway et al., 2017; Santiesteban et al., 2014; Schurz et al., 2015), results suggest that domain-general attentional processes, rather than a domain-specific process such as implicit mentalizing, underlie performance on the task. However, a recent neuroimaging study claimed to have found evidence of domain specificity at the neural level using the dots task (Schurz et al., 2015). Schurz and colleagues reported greater activation of brain regions generally associated with mentalizing such as rTPJ, medial prefrontal cortex (mPFC) and ventral precuneus when participants made self-perspective judgements in the mentalistic (avatar) but not in the non-mentalistic (arrow) condition.

We recently suggested that neuroimaging methods are ill-suited to address claims of implicit mentalizing due to the fact that, under an implicit mentalizing account, the presence of a mentalistic stimulus is sufficient to prompt the mentalizing process. Thus, it is impossible to determine whether differential activation is caused by the stimulus (the avatar), or the process of interest (mentalizing), when contrasted with a non-mentalistic stimulus such as an arrow (see Catmur et al., 2016). In the present study, we use both behavioural (Experiment 1) and brain stimulation (disruptive repetitive transcranial magnetic stimulation – rTMS – of rTPJ, Experiment 2) methods to provide an empirical test of the claim that rTPJ is involved in representing another's visual perspective during self-perspective judgements for mentalistic, but not for non-mentalistic, stimuli. In both experiments all participants completed the dots task in two stimulus conditions, where the central stimulus was either mentalistic (avatar) or non-mentalistic (arrow). Should stimulation of rTPJ result in impairment of self-perspective judgements in the avatar but not in the arrow condition, this would provide support for the domain-specific claim. Conversely, if stimulation of rTPJ fails to distinguish between the avatar and arrow trials, this would favour a domain-general attentional interpretation of performance on this task.

Although domain-general accounts of performance on the dots task have been proposed, the nature of any such domain-general processes has been relatively under-specified and, as far as we are aware, no study has provided positive evidence for their existence. Consideration of the task demands of the different conditions can help elucidate the nature of any such processes. For example, on self-perspective trials, the participant must overcome any attentional cuing effect of the avatar and arrow, and re-orient their attention to scan the whole room for the presence of dots (both in front of and behind the central stimulus). In contrast, on non-self-perspective trials the participant does not need to reorient their attention after it has been allocated to the side of the room cued by the central stimulus, as this is the only side that must be searched for dots. This analysis would indicate that domain-general processes involved in attentional reorienting should be required on self-perspective, but not on non-self-perspective trials. Another possibility is that the saliency of the dots makes them 'pop-out' compared to the background. On self-perspective trials, participants could use attentional processes in combination with this pop-out effect to select all the dots, following which the number of dots would be automatically subitized (Sathian et al., 1999). The use of attentional selection to profit from this 'pop-out and subitization' process would be helpful on self-perspective trials, as it would result in the correct number of dots being identified; but on non-self-perspective trials, such attentional selection of all red dots would be counterproductive. Again, this analysis indicates that different domain-general attentional processes would be involved on self-perspective than on non-self-perspective trials.

Crucially, previous fMRI studies using the dots task have reported stronger activation of rTPJ for self- than for non-self-perspective judgements (Ramsey et al., 2013; Schurz et al., 2015); a finding which is consistent with the task-demand analyses above, given that the TPJ has a well-documented role in certain domain-general attentional processes including attentional reorienting and visual pop-out (Buschman and Miller, 2007; Corbetta and Shulman, 2002; Ellison et al., 2004; Geng and Vossel, 2013; Pollmann et al., 2003), but not in others such as endogenous orienting of attention (Thiel et al., 2004). Therefore, a domain-general attentional account of performance on this task would be supported by data whereby stimulation of rTPJ fails to distinguish between mentalistic and non-mentalistic trials during self-perspective judgements, yet selectively affects self-perspective trials compared to non-self-perspective trials.