Acta Psychologica 169 (2016) 71–78

Contents lists available at ScienceDirect

Acta Psychologica

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

Observed bodies generate object-based spatial codes

Alison Taylor [a], Maria Flynn [a], Caroline J. Edmonds [b], Mark R. Gardner [a,*]

[a] Department of Psychology, University of Westminster, 115 New Cavendish Street, London W1W 6UW, United Kingdom
[b] School of Psychology, University of East London, Stratford Campus, Water Lane, London E15 4LZ, United Kingdom

ARTICLE INFO

Article history:
Received 17 September 2015
Received in revised form 9 May 2016
Accepted 17 May 2016
Available online 25 May 2016

Keywords:
Body representation
Perspective taking
Own body transformation
Implicit mentalising
Spatial compatibility
Simon effect

ABSTRACT

Contemporary studies of spatial and social cognition frequently use human figures as stimuli. The interpretation of such studies may be complicated by spatial compatibility effects that emerge when researchers employ spatial responses, and participants spontaneously code spatial relationships about an observed body. Yet, the nature of these spatial codes – whether they are location- or object-based, and coded from the perspective of the observer or the figure – has not been determined. Here, we investigated this issue by exploring spatial compatibility effects arising for objects held by a visually presented whole-bodied schematic human figure. In three experiments, participants responded to the colour of the object held in the figure's left or right hand, using left or right key presses. Left-right compatibility effects were found relative to the participant's egocentric perspective, rather than the figure's. These effects occurred even when the figure was rotated by 90° to the left or to the right, and the coloured objects were aligned with the participant's midline. These findings are consistent with spontaneous spatial coding from the participant's perspective and relative to the normal upright orientation of the body. This evidence for object-based spatial coding implies that the domain general cognitive mechanisms that result in spatial compatibility effects may contribute to certain spatial perspective-taking and social cognition phenomena.

1. Introduction

Effective social interaction often relies upon spatial coordination between oneself and a third party. There is current interest in whether such coordination is mediated by domain general processes or specialised information processing mechanisms, for abilities including imitation (Catmur & Heyes, 2011; Cooper, Catmur, & Heyes, 2012), mentalising (Heyes, 2014; Santiesteban, Catmur, Hopkins, Bird, & Heyes, 2014), and spatial perspective-taking (Gardner & Potts, 2011; May & Wendt, 2012, 2013). An important aspect of these domain general accounts is stimulus-response (S-R) compatibility between spatial codes generated for an observed body and for one's own body. Spontaneous object-based spatial coding that could drive such spatial compatibility phenomena has been demonstrated for faces and inanimate objects, using a modified Simon paradigm (Pick, Specker, Vu, & Proctor, 2014; Proctor & Pick, 1999). However, similar evidence for object-based spatial coding has yet to be demonstrated for observed human figures. Given the ubiquity of avatars, and other visual representations of human figures as stimuli in social and spatial cognition research (e.g., Cole, Smith, & Atkinson, 2015; Kessler & Thomson, 2010; Lawson, Clifford, & Calder, 2009; Mazzarella, Hamilton, Trojano, Mastromauro, & Conson, 2012; Pan & Hamilton, 2015; Samson, Apperly, Braithwaite, Andrews, & Bodley Scott, 2010; Zacks, Mires, Tversky, & Hazeltine, 2000), the aim of the current study was to employ a modified Simon paradigm in order to examine the nature of the spatial codes spontaneously generated when observing visual whole body depictions of the human figure.

Stimulus-response (S-R) compatibility effects are indicated by response times that are faster when there is a congruent relationship between stimulus and response than when there is not (Proctor & Reeve, 1990). Spatial compatibility occurs through correspondence between the location of a stimulus and the location of the response, and encompasses the Simon effect, where reaction times are faster if the stimulus occurs in the same spatial location as the response, even though the spatial location of a stimulus is formally irrelevant to the task (Simon, Hinrichs, & Craft, 1970; Proctor & Vu, 2006). Simon effects have been accounted for by the dual-route model (Komblum, Hasbroucq, & Osman, 1990) which proposes that the irrelevant spatial location elicits an automatic spatial code which primes the congruent response. The second route involves an intentional spatial code dependent upon the task relevant feature of the stimulus and its appropriate response. When these two spatial codes are non-corresponding it causes response competition resulting in slower reaction times, and a Simon effect is observed (Hommel, Proctor, & Vu, 2004).

Domain general processes, such as spatial S-R compatibility, have been put forward as an alternative account for findings previously ascribed to "implicit mentalising" - the unconscious and automatic

* Corresponding author.
E-mail address: m.gardner@westminster.ac.uk (M.R. Gardner).

http://dx.doi.org/10.1016/j.actpsy.2016.05.009
0001-6918/

representation of others' mental states (Frith & Frith, 2012; Heyes, 2014). Heyes (2014) uses the example of experiments where participants appear spontaneously to adopt the mental states of a triangle stimulus, provided it is moving in 'goal-directed' patterns designed to resemble the actions of intentional 'agents' (Zwickel, 2009). Participants are asked to make left/right spatial responses about the location of a dot in relation to this stimulus, but from their own egocentric perspective. Reaction times are faster when the perspective of the participant corresponds with that of the triangular agent (upright triangles) than when they do not correspond (inverted triangles). This congruency effect was interpreted as evidence that participants automatically and unconsciously represent mental states from the visuospatial perspective of the triangle stimulus via specialised cognitive mechanisms (Zwickel, 2009). However, Heyes (2014) points out that object-based spatial compatibility (Hommel & Lippa, 1995; Proctor & Pick, 1999; Pick et al., 2014) can also account for these findings. Specifically, for the inverted triangles, response competition between the spatial location of the dot in relation to the triangle (task irrelevant), and the spatial location of the dot in relation to the participant (task relevant) could generate a Simon effect (Heyes, 2014; Pick et al., 2014).

Domain general processes including spatial compatibility effects have also been advanced to account for spatial perspective-taking phenomena, such as the results from experiments employing the 'own-body transformation' (OBT) task (Blanke et al., 2005). The OBT task requires participants to make a left or right spatial decision regarding an object placed in the left or right hand of a front- or back-facing human figure, and made from the spatial perspective of the figure. Results have consistently shown longer reaction times for front-facing figures, when the perspective of participant and the figure differed, than for back-facing figures when perspectives matched. This finding has been interpreted as evidence that people adopt a third party perspective by a specialised process that involves mentally transforming one's own body through space (Blanke et al., 2005; Mohr, Rowe, & Blanke, 2010; Zacks et al., 2000). By contrast, the domain general account proposes that this difference arises because stimulus-response mappings are spatially compatible for back-facing figures, and spatially incompatible for front-facing figures (Gardner & Potts, 2011; Gardner, Brazier, Edmonds, & Gronholm, 2013; Gronholm, Flynn, Edmonds, & Gardner, 2012; May & Wendt, 2012, 2013).

Gardner and Potts (2011) report a series of experiments that provide support to the domain general spatial compatibility account of OBT task performance. Manipulations known to influence spatial compatibility effects were found to moderate performance in the OBT task. Specifically, the difference in reaction times between the front- and back-view stimuli was found to be diminished for vocal responses compared to manual responses, consistent with a reduction in dimensional overlap between stimulus and response (Kornblum & Lee, 1995). In addition, this effect was reversed for a crossed hands manipulation that alters the direction of spatial compatibility effects (e.g., Brebner, Shepard, & Cairney, 1972). Moreover, performance for the OBT task was indistinguishable from that of a 'non-corporeal' control task that involved the equivalent stimulus-response mappings in the absence of a representation of the human figure. Taken together, these findings imply that spatial compatibility contributes to OBT task performance. However, this domain general account assumes that the left/right spatial codes elicited for observed figures are spontaneously coded, and specific to the viewer's perspective (which side?) rather that of the figure (which hand?), despite the task relevance of the figure's hand. These assumptions have yet to be tested.

The Simon paradigm offers a useful technique with which to examine these assumptions. By manipulating spatial location as a task irrelevant factor, the presence of a Simon effect can reveal the automaticity and nature of spatial coding (Lu & Proctor, 1995; Hommel, 2011). The standard Simon task asks participants to make left-right responses to a spatially irrelevant feature of a stimulus, e.g. colour, whilst stimuli are placed in varied spatial locations (Simon & Rudell, 1967). A Simon effect - a compatibility effect between the task irrelevant spatial location of the stimulus and the spatial location of the response key - indicates that actions are affected by parts of stimuli not relevant to current action goals (Hommel & Prinz, 1997).

Spontaneous coding of spatial relationships about observed whole body stimuli has yet to have been investigated using a Simon paradigm. However, a Simon paradigm has revealed evidence that observed hands and feet automatically generate 'sidedness' codes, representing the side that this body part is normally seen to occupy from an observer's visuospatial perspective (Ottoboni, Tessari, Cubelli, & Umilta, 2005). Such sidedness codes have been revealed when the task irrelevant hand or foot stimuli has been correctly attached to the forearm/ankle (Tessari, Ottoboni, Baroni, Symes, & Nicoletti, 2012). This occurs when the hand/forearm configuration is presented in isolation (Ottoboni et al., 2005), or presented in a spatially compatible position relative to an undersized body (Ottoboni et al., 2005, or non-bodily figures (Tessari, Ottoboni, Symes, & Cubelli, 2010). Sidedness effects do not occur when the spatial code elicited by the hand/forearm configuration is incompatible with the spatial position that the hand occupies relative to a body (Tessari et al., 2010), which may be taken to imply that people are sensitive to the biomechanical constraints of these stimuli. These findings have been interpreted as evidence of a domain specific process whereby the visual appearance of the hand-forearm configuration provides direct access to the body structural description, a representation of topological relationships about one's own or another's body.

By contrast, evidence for the automatic generation of object-based spatial codes has been revealed previously using the Simon paradigm for objects other than bodies, including both faces and inanimate objects (Hommel & Lippa, 1995; Pick et al., 2014; Proctor & Pick, 1999). For instance, when imperative stimuli were presented within a face context that had been rotated in the picture plane by 90° clockwise or counter-clockwise, compatibility effects were found that depended upon whether the location that the stimulus had been presented would be seen as left or right relative to the face viewed in the standard upright position (Hommel & Lippa, 1995). Similar object-based compatibility effects also have been reported for stimuli relative to inanimate external reference frames, such as road signs, tilted by 90° from normal upright orientation (Pick et al., 2014). Such evidence of object-based spatial coding for varied stimuli suggests that similar findings might be observed for any object with a normal upright orientation and a clear midline. Human figures are one such object, but to our knowledge this phenomenon has not been investigated for whole body human stimuli independent of the contribution of the visual appearance of the hand/forearm investigated by Ottoboni and colleagues.

Evidence for object-based spatial coding for visually presented whole body stimuli would have a bearing on evidence for imagined perspective transformations in the OBT task. May and Wendt (2012) found that response times for laterality judgments were elevated for the front-facing relative to the back-facing figures, even when the schematic figures were presented at an angle tilted by 90° from normal upright orientation. This condition was designed to be neutral with respect to spatial compatibility in that the hands of the schematic figure varied in a dimension (up/down) orthogonal to that of the response keys. Consequently, results from the 90° condition were interpreted as evidence for imagined perspective transformations, independent of the influence of spatial compatibility. However, spatial compatibility could still have contributed to these results if left-right codes are generated for human figures with respect to the normal upright orientation of a figure, and from the point of view of the participant, in keeping with an object-based spatial coding account.

The current series of experiments employed a modified Simon procedure in order to examine the nature of the spatial codes generated for observed schematic human bodies. Schematic stimuli were used on the basis that the critical factor was that left and right should be discernable, rather the degree to which the figure appeared lifelike (Proctor & Pick, 1999). Participants responded to the colour of ball