SELECTIVE DEFICIT OF IMAGINING FINGER CONFIGURATIONS

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INTRODUCTION

Among the paradigms used to investigate motor imagery, the one for which the processing components are best understood is the paradigm that requires the participants to decide whether a hand presented in different orientations is a left or a right hand (Parsons, 1987). Parsons argued that in order to carry out this task, participants mentally rotate a representation of their own body part until it aligns with the stimulus. The time required to complete the mental rotation of the body part is an approximately linear function of the size of the angle required to superimpose the virtual to the presented image, as it is for the mental rotation of external, visual objects. However in contrast with the situation for objects, the imagined trajectory for the observer's body part is strongly influenced by biomechanical constraints specific to its actual movement. Consistently with this position Kosslyn et al. (1998) argued on the basis of imaging data that motor imagery is involved in making implicit transformations of the viewer's hands but not in that of external objects, and that the former operation recruits motor processes while the former does not. The question posed in this paper is whether neuropsychology can provide evidence in support of this view. While patients with a selective deficit in mentally rotating external objects have been documented (e.g. Bricolo et al., 2000), no cases with a selective deficit in rotating body parts have yet been described.

The case presented in this paper is that of a patient with a selective deficit affecting his ability to mentally rotate his hands (and in particular finger configurations) whereas the mental rotation of external objects was preserved.

NEUROPSYCHOLOGICAL EVALUATION

MT is a right-handed Italian man, born in 1951, with no previous neurological history and with 17 years of schooling. In 1998 he was admitted to the hospital with right hemi-paresis and aphasia caused by a stroke. A CT-scan revealed an ischemic lesion in the left hemisphere involving the Brodmann Areas 44, 43, 40, 4 and the basal ganglia. His neuropsychological profile is reported in Table I. Interestingly, MT showed a deficit in deciding whether line drawings of body parts, in particular hands, depicted a left or a right hand, whilst his performance in a task in which mental rotation of external objects was involved was well within the normal range. He participated in a series of experiments to investigate i) the level of impairment of motor imagery (hands versus finger configurations), in contrast with ii) his relatively preserved ability to mentally manipulate representations of shown objects.

TABLE I
MT's scores on standardized tests.
For further details concerning these tests see Tomasino et al. (in press)

			MT	Controls
Intelligence	WAIS	Total	93	100 ± 15
	Raven Matrices		50/60	
Language	Aachener Aphasie Test		Broca's	
Vision	BORB	Foreshortened View match	25/25	21.60 ± 2.6
		Association match	30/30	27.50 ± 2.4
	VOSP	Object decision	18/20	17.70 ± 1.9
Praxis	Action recognition	Pantomimes	15/15	15/15
	Real use	Single objects	28/28	23.20 ± 1.78
	Imitation of limb movements		45/72	Cut-off = 53
	Pantomiming	Visual	17/28	20.20 ± 2.93
		Tactile	19/28	20 ± 2.67
		Verbal command	23/28	19.93 ± 3.3
Motor rotation	Right-left decision	Hands	23/40	37/40
		Arms	21/26	26/26
		Feet	24/26	26/26
Body knowledge	Pointing & imitation	Body parts	normal	
Mental rotation	Flags test		50/60	21/27 to 52/55

Experiments 1 and 2

In Experiment 1 MT's ability to overtly make a movement with his own left or right hand until it matched the seen target (open hand) was tested. In Experiment 2, not only was MT required to implicitly move his hand into congruence with the target, he was also asked to shape his fingers into the same configurations as the fingers in the stimulus.

Experiment 1: Right-left decision of hands

Methods

MT was shown one hundred and twenty photographs of hands, of which 50% were left hands and 50% right, on a computer screen. Stimuli differed by view (i.e. palm, back, thumb, little finger, wrist), and orientation (by steps of 30 degrees, from 0 to 330). MT and 10 controls matched for age (mean = 48.2 ± 10.32; range 32-64) and education (mean = 11.5 ± 2.41; range 8-13) were asked to say whether the stimulus depicted a right or a left hand.

Results

MT was as accurate (112/120, 93.0%) as the controls (range 102-120, mean = 110.20, 92.0.4%, SD = 5.71) in performing this task (z = 0.3, p = 0.38). Neither MT nor the controls showed an effect of handedness, view or orientation.

Experiment 2: Right-left decision of finger configurations

Methods

Design and procedure were the same as for Experiment 1 except that the photographs of open hands were substituted by three different finger configurations for a total of 360 stimuli.

Results

MT performed pathologically (279/360, 77.5%) compared to controls (range 338-354, mean = 344.9, 96.%, SD = 5.4) on this task (z = – 12.2, p = 0.001). Once again, as in Experiment 1, MT did not show an effect of handedness (left-right), but in this experiment he did have difficulty with views (p = 0.01) and orientation (p <0.001). The views that MT found most problematical were from the back (65.27% of correct responses) and from the thumb (76.38% of correct responses), by contrast the orientations that caused him most difficulty were 120° (56.66% of correct responses), 150° (60% of correct responses) and 180° (46.66% of correct responses). Controls showed only an effect of view (p= 0.01).

Experiment 3: Matching a hand posture to a real object

Methods

MT and controls (N = 13) were required to select, out of four alternatives, the photograph of the hand posture consistent with grasping a real object placed in front of him, while keeping his own hands perfectly still. A total of 40 trials were given, in which twenty objects were shown twice, once with the graspable feature to the right side and once to the left side.

Results

MT’s performance was outside the normal range (MT: 28/40, 70.%; controls: range 35-40, mean = 37.53, 94%, SD = 1.4).

Experiments 4: Mental rotation of external objects

With this experiment we aimed to replicate the result obtained by MT with the Flag test and suggesting that he is able to mentally rotate external objects.

Methods

MT and five controls were asked to match a three-dimensional branching form (see Shepard and Metzler, 1971) to one with the same (baseline condition) or with different orientation (rotation condition). There were 40 trials with three alternatives in each.

Results

MT scored 19/20, 95%, in the baseline condition and 16/20 (80%) in the rotation condition. MT's performance was close to the normal range in the baseline condition (mean = 20, 100%) but fell within the normal range in the rotation condition (range 12-16, mean = 14, 70.% SD = 1.58).

DISCUSSION

MT was as accurate as controls in recognizing a left hand from a right hand when the stimuli consisted of open hands (Experiment 1). However his scores in Experiment 2 revealed a deficit in mentally shaping his hand until it matched the hand stimulus when this involved finger postures. This finding was consistent with the difficulties he encountered in matching hand postures with shown objects. Moreover, the finding that MT was less accurate than controls on uncomfortable orientations of the stimuli (target hands) demonstrate that the processes associated to left-right body part judgements (particularly fingers), and best modelled in somatic or biomechanical space (Parsons, 1987), are impaired in MT. In contrast, processes implicated in mental rotation of object shapes – best modelled in a visual space – are operating satisfactorily in this patient.

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