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# Recognition of hand shape drawings on vertical and horizontal displa

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**Abstract**

The visual recognition of body parts activates somato-motor representations in the brain. In the present study, we investigate the influe of the plane in which hand drawings are displayed (Vertical or Horizontal) on mental rotations evoked by a handedness recognition t Sixteen right-handed volunteers participated in an experiment where the task was to evaluate the handedness of drawings of the hu hand presented in different perspectives and orientations while the Manual Reaction Time (MRT) was measured. For eight volunte the hand drawings were displayed on a vertical screen monitor, while for the remainder a mirror was employed and the same drawi appeared on the horizontal plan. Our main finding was that there are no differences in MRTs among the drawings displayed vertic or horizontally, with some exceptions. However, the MRTs were longer when the hands in the drawings assumed configurations were more awkward to perform using real movements. These results show that the implicit movements involved with handedn recognition are mainly dependent on biomechanical constraints for distal (hand), but not proximal (shoulder) movements. **Keywor** handedness recognition, motor imagery, manual reaction time, visual representations, sensorimotor representations.

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## Introduction

The visual recognition of body parts activates somato-motor representations in the brain in a way similar to motor imagery (Parsons, 1994; Jeannerod & Decety, 1995; Decety, 1996). These representations are implicitly activated in order to compare the stimulus with one's own body (Parsons, 1994; Parsons & Fox, 1998).

Parsons (1987, 1994) showed that the time required to discriminate the handedness of a hand drawing depends on the perspective and the orientation of the drawing and is similar to the time necessary to perform either a mental movement of one's own hand or the corresponding real movement. Mental rotation is an essential component of handedness recognition, motor imagery and the actual movement planning. Surprisingly, however, the biomechanical constraints normally imposed on the movement of body segments also have to be taken into account during the mental rotation of body parts, such the hand (Petit, Pegna, Mayer, & Hauert, 2003).

Movements that are difficult to be executed, instance, are also difficult to be mentally reproduced lead to longer reaction times in handedness judgme The mentally simulated movement activates somato-mo representations in the cerebral hemisphere contralatera the limb (Parsons, Gabrieli, Phelps, & Gazzaniga, 199

Parsons (1987, 1994) proposed a model for handedn recognition containing five steps: 1) pre-attent recognition of handedness; 2) analysis of the orientat of the internal representation of the corresponding hand planning of the rotation movement toward the orientat of the stimulus; 4) mental simulation of the plan rotation and 5) "confirmatory" matching between internal representation of the hand and the visual stimu In this model, information about stimulus handedness derived in the early pre-attentive stages of informat processing, but the later mental simulation of movem and the confirmatory matching operation provide necess confirmation for conscious decision-making (Pars & Fox, 1998). This model can be further abbreviated consisting of only two phases: a pre-attentive handedn recognition process followed by a confirmatory mo

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& Gangitano, 1998). The automatic recognition phase relies on "internal models" that are constructed by motor experience (Wolpert, Ghahramani, & Jordan, 1995), while motor imagery follows the same rules of the real movement, including compliance to physical constraints (De Lange, Helmich, & Toni, 2006; Parsons, 1994; Vargas et al., 2004).

One important question raised by Parsons in his 1994 seminal paper was if, in a handedness judgment task, motor imagery would be affected by modulating proprioceptive information coming from the actual limb through posture variation. The results showed that the time spent for mentally rotating one's own hand is shorter when the hand is actually kept in a "canonical" posture than when it is maintained in a more awkward one.

The same result was obtained in a study using Transcranial Magnetic Stimulation (TMS) (Vargas et al., 2004). The authors reported that the corticospinal tract excitability facilitated by TMS during the mental simulation of a hand movement is affected by the actual hand posture. Similarly, De Lange et al. (2006) reported in an fMRI study that handedness judgments activated a parieto-frontal network whose activity increased with increasing biomechanical complexity of the imagined hand movements, even when the amount of stimulus rotation was identical. Moreover, activity in the intraparietal sulcus was modulated by the volunteers' own hand position. These results indicate that motor imagery may be influenced in real time by intrinsic factors such as the proprioceptive information coming from the limbs.

The Manual Reaction Times (MRTs) in a handedness discrimination task should be dependent not only on the orientation and the view of the hand drawings, but on the sequence of movements necessary to achieve the task, as shown by Parsons (1994). For instance, how does the involvement of proximal muscles affect the intrinsic movements involved with the handedness recognition task? In order to answer this, we measured the MRTs in a handedness task with the drawings located either on the horizontal or the vertical plane.

## Methods

*Subjects*

Sixteen right-handed volunteers (Oldfield, 1971) participated in this study (seven male and nine female, 18-23 years old, *M* = 19.5 years). All had normal or corrected visual acuity and were naïve as to the purpose of the experiment. Written informed consent was obtained from all volunteers and the study was approved by our institution's Research Ethics Committee.

*Apparatus*

The stimuli were drawings of the right and left human hand in several views (see Fig 1A) and in several orientations) were used. Each stimulus was presen twice.

*Procedure*

The experiment was conducted in a quiet and dimly room. A PC computer (Intel 486) was used both for stim presentation and to record the volunteer's response. T participants positioned their heads so that the distan between the eyes and the screen was about 57 cm. T Micro Experimental Laboratory software (MEL, vers 2.0) was used to determine the events' sequences and measure response latency. The stimuli measured ab 13.5 deg by 7.3 deg and were displayed at the center o 20 inch (50.8 cm) VGA monitor. The stimulus remain on the screen until the execution of a response and volunteers responded by pressing one of two mic switches, one located to the left and the other to the ri of their midline, depending on the laterality of the ha drawing (left or right, respectively). Half of the volunte executed the task looking directly at the computer disp (vertical condition). For the other half, the task w executed looking at the image of the screen as reflec in a mirror located in front of the participant, giving illusion that the viewing surface was horizontal (Fig. When watching the horizontal drawing, the volunteer h to look downwards onto a mirror. The vertical stimulus w outside the upper visual field and did not interfere with horizontal stimulus processing.

Each trial started with the stimulus appearing at center of the screen. Volunteers were instructed to respo as fast as possible by pressing the right micro-switch t stimulus depicting a right hand and the left micro-swi to a stimulus depicting a left hand. After a 500 ms interv a new trial began. Participants attended one session. T session was subdivided into 3 blocks of 80 trials, result in 240 trials per session.

*Data analysis*

For each view and angle the medians of the corr MRTs was calculated. The MRT for left and right ha drawings (left and right response keys, respective were pooled together. Using an experimental des similar to that proposed by Parsons (1994), analyzed the effect of hand angle on MRT for ea view, separately. Moreover, we compared the MRTs Vertical and Horizontal presentations. We perform five Analysis of Variances (ANOVAs), one for each vi (Figures 3-7) with a between subject factor (Vertical Horizontal plane) and a within subject factor (angl Post-hoc comparisons were done using the Newm Keuls method.

## Results

*Back view*

Figure 3 presents the mean (± SEM) of

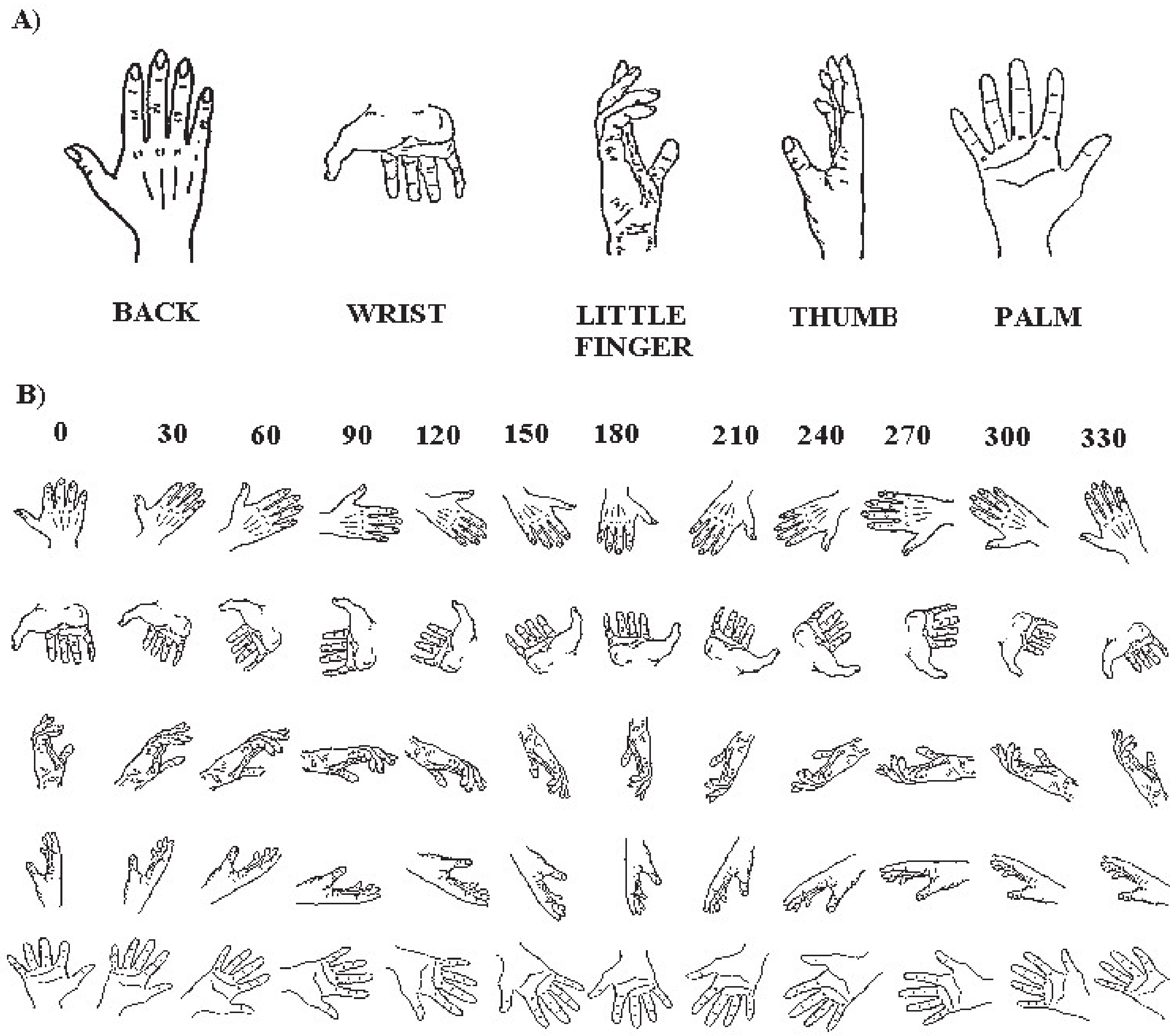


**Figure 1.** (A) Drawings of the right hand in the perspectives employed in this study. (B) Drawings of the right hand with angles varying fro
to 330 deg. During the experiment, drawings for the left (not illustrated) and right hands for each view and angle were randomly presented

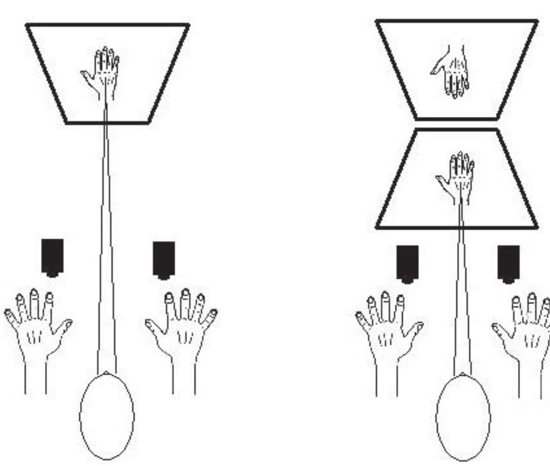

**Figure 2**. Schematic drawings showing the setup for handedness

$F(1, 14) = 0.17$, $p = .68$) between the MRTs
drawings viewed at the vertical and horizontal plan
neither an interaction between plane and ang
$F(11, 154) = 1.45$, $p = .16$. Only angle was a signific
factor in modulating MRTs, $F(11, 154) = 16.40$, $p < .0$
The post-hoc analysis showed significant differen
($p < .05$) among the following MRTs (Fig. 3): 1) M
for a drawing oriented at 180 deg (2148 ms) is lon
than all others; 2) MRT for a drawing oriented
150 deg (1702 ms) is longer than all others, except
180 deg; 3) MRT for a drawing oriented at 210 a
240 deg (1392 and 1350 ms) are longer than 0, 300 a
330 deg (951, 878 and 874 ms). 4) MRT for a draw
oriented at 90 (1344 ms) is longer than 0, 300 and 330 d
(951, 878 and 874 ms).

No other comparison was statistically significa
These results are in agreement with the Parson

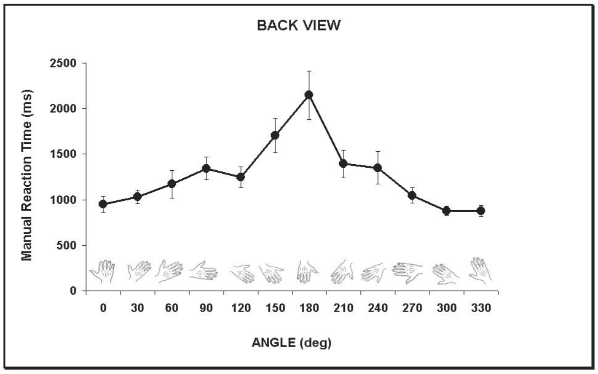


**Figure 3**. Graph showing the mean (+ SEM) of the MRT for back view as a function of hand drawing orientation.

also difficult to be mentally reproduced leading to delays in handedness judgment due to biomechanical constraints.

*Wrist view*

Figure 4 depicts the mean (± SEM) of MRT for wrist view as a function of hand drawing orientation. There were no significant differences, $F(1, 14) = 0.24$, $p = .63$, between the MRTs for vertical and horizontal drawings nor an interaction between plane and angle, $F(11, 154) = 1.78$, $p = .06$.. Angle was a significant factor, again,, $F(11, 154) = 4.60$, $p < .001$, and the

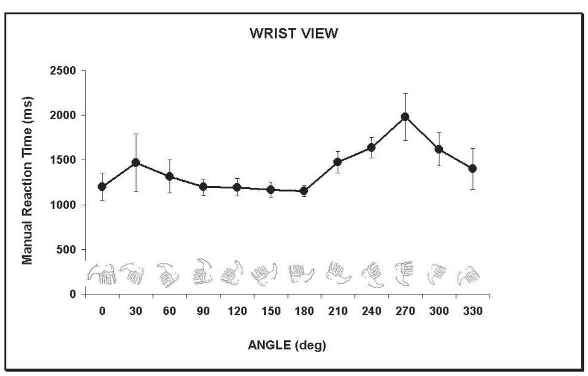


**Figure 4.** Graph showing the mean (+ SEM) of MRT for wrist view as a function of hand drawing orientation.

post-hoc analysis showed that the MRT for the 270 deg angle (1982 ms) is longer than all others, except for the MRT for the 300 deg angle (1621 ms). No other comparison was statistically significant.

*Little finger view*

Figure 5 shows the mean (± SEM) of MRT for little finger view as a function of hand drawing orientation.

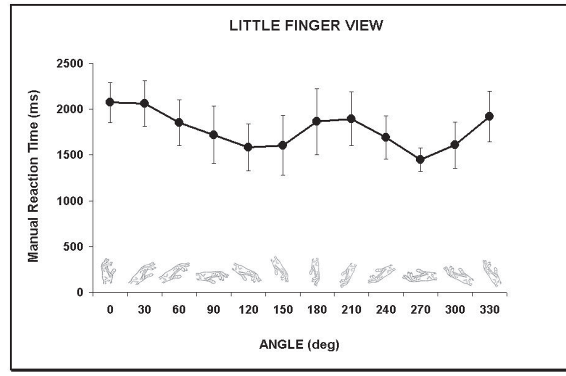


**Figure 5**. Graph showing the mean (+ SEM) of MRT little finger view as a function of hand drawing orientatio

drawings nor any interaction between plane and ang $F(11, 154) = 1.60$, $p = .10$. Angle was a signific factor, $F(11, 154) = 2.30$, $p < .01$, and the post-h analysis showed that the MRT for drawings oriented 270 deg (1451 ms) is shorter than the MRT for both 0 (2074 ms) and 30 deg (2063 ms). No other comparis was significant.

*Thumb view*

Figure 6 presents the mean (± SEM) of M for thumb view as a function of hand draw orientation. There were no significant differenc

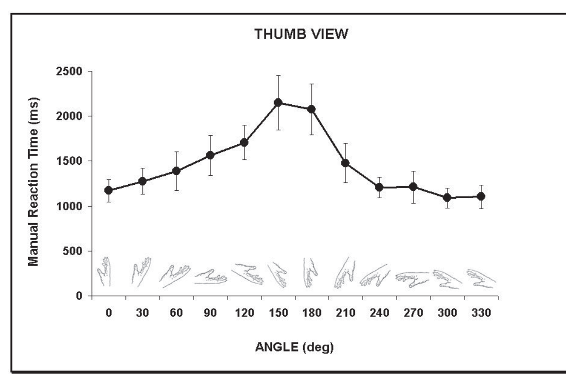


**Figure 6**. Graph showing the mean (+ SEM) of MRT thumb view as a function of hand drawing orientation.

$F(1, 14) = .04$, $p = .84$, between MRTs for verti and horizontal drawings nor any interact between plane and angle, $F(11, 154) =$ . $p = .71$. Angle was a significant factor, $F(11, 154) = 10.$ $p < .001$, and the post-hoc analysis showed th 1) MRTs for 150 deg (2148 ms) and 180 deg (2077 m are longer than MRTs at any other angles. 2) MR for 120 deg (1707 ms) is longer than 0, 240, 270, 3

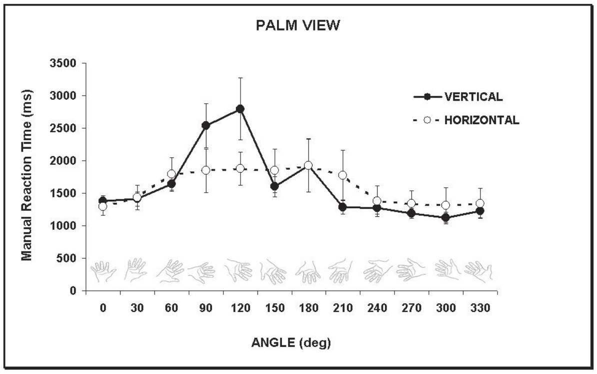


**Figure 7.** Graph showing the mean (+ SEM) of MRT for palm view presented in vertical and horizontal plan as a function of hand drawing orientation.

*Palm view*

Figure 7 indicates the mean (± SEM) of MRT for palm view presented in vertical and horizontal plan as a function of hand drawing orientation. There were no significant differences, $F(1, 14) = .01$, $p = .94$, between MRTs for vertical and horizontal drawings. This is the only view in which there was an interaction, $F(11, 154) = 2.142$, $p = .02$, between plane and angle. Angle was a significant factor, $F(11, 154) = 7.72$, $p < .001$, and the post-hoc analysis showed that: 1) in the vertical plane, MRTs for 90 deg (2191 ms) and 120 deg (2335 ms) are longer than MRTs at any other angles and 2) in the horizontal plane, there is no significant difference among the MRTs at the several angles.

## Discussion

Parsons (1987, 1994) showed that the time required to discriminate the handedness of a hand drawing was similar to the time necessary to move one's own hand towards the stimulus configuration or to perform a mental simulation of the same movement. This mental rotation is the efferent copy of the actual movement without any muscle activation. It has been shown that the mental rotation of body parts, such as the hand, has to take into account the biomechanical constraints imposed on the actual movement of body segments (Petit et al., 2003). Movements that are difficult to be executed, for instance, are also difficult to be mentally reproduced and lead to longer response times.

At this point, it is worth noticing that Parsons' experimental approach, that has been largely employed for the study of motor imagery (Sirigu & Duhamel, 2001; Ionta, Fourkas, Fiorio, & Aglioti, 2007) and its neural correlates, has also been used for investigating neurological afflictions both in adults (Fiorio, Tinazzi, & Aglioti, 2006) and children (Wilson et al., 2004). (Gawryszewski, Silva-dos-Santos, Santos-Sil
Lameira, & Pereira, 2007). Since the actual movem
towards a hand drawing located in the vertical pl
are biomechanically diverse than the movement aim
at a hand drawing located in the horizontal pla
due mostly to the differential activation of proxi
muscles, we wondered whether the mental rotatio
corresponding to these movements would also
different, even if the stimulus was actually the same
both cases.

Our results showed that, for some views (back, li
finger, thumb, wrist and palm) there is no signific
difference between the MRTs for vertical and horizo
drawings (neither an interaction between plane a
angle). The only minor exception occurs for the pa
view, in which there is an interaction between plane a
angle, Thus, there is no obvious difference between
mental rotations aimed at providing the confirmatory
for handedness judgments of drawings located in eit
the vertical or horizontal plane.

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