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Research Report

Simulated actions in the first and in the third person perspectives share common representations

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ABSTRACT

Normal subjects simulated a grasping action with two levels of difficulty of the grasp. In one condition, they simulated the movement from their own, first person perspective (1P). In the other condition, they simulated the same movement made by a person facing them (third person perspective 3P). The time to complete the movement was found to be closely similar in the two conditions. Furthermore, the same difference in simulation time between easy and difficult grasps was retained in the two conditions. These results show that a self-generated and an observed action share the same representation. This representation can be used from different perspectives.

1. Introduction

Trying to understand the actions of another person implies that one adopts her point of view on the external or the social world. The popular expression of "putting oneself in the other's shoes" accounts for this idea of taking the perspective of the person one observes. By taking the other's place I see things as she would see them. But, at the same time, I experience how an action she performs would be if I were doing it myself. This suggests that the representation I use to understand the action of another person must be close to the representation I build for performing that same action.

In the experiments reported in this paper, we attempted to compare action representations corresponding to either self-generating an action or observing the same action performed by someone else. In order to make the two situations compatible with one another, that is, to compare action representations in the absence of overt execution in both situations, we took advantage of the paradigm of motor imagery. Normal participants were instructed to adopt different perspectives in mentally simulating the same grasping action: they had either to imagine themselves performing the action from their own perspective or to imagine another person facing them performing the same action. One of the problems inherent to motor imagery tasks, however, is that the subject's performance is relatively opaque to the experimenter. To overcome this problem, it is possible to use a "mental chronometry" method where subjects provide estimates of the time to complete the simulated action. This method has proven to give reliable and replicable results (Decety et al., 1989; Sirigu et al., 1996). Here we adopted a grasping task designed by Frak et al. (2001). These authors found that grasping an object with an unnatural orientation of the hand takes longer than grasping the same object with a more natural orientation. Furthermore, and most importantly, they also found that a similar time difference holds in mentally simulating the same task. This finding not only provides evidence that mentally simulated actions follow the same constraints as really executed ones (for a review, see Jeannerod, 2006); it also provides an objective measure of what a subject is actually doing when instructed to simulate grasping an object at different orientations.

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In the experiment reported in this paper, we used this measure to probe the strategy of normal subjects who either executed the task of grasping an object, or simulated the same motor task from their own, first person perspective or from the perspective of another person facing them. Our working hypothesis was twofold. First, we hypothesized that, in accordance with previous data, the subjects would use for simulating the action a representation that would be similar to that used for executing it. Second, we further hypothesized that the subjects would use the same representation for simulating the same action from the two different perspectives.

2. Results

2.1. Simulation trials

In the two simulation conditions, the difference between mean response time for simulating the difficult (0°) and the easy (45°) grasping movements was in the range of 150–170 ms (176 ms in the 1P condition; 157 ms in 3P condition) (see Table 1).

The repeated measures ANOVA using subject ($N=29$), condition (1P, 3P), angle of grasp (0°, 45°) and diameter of the cylinders (3, 4, 5 cm) as main factors, showed a main significant effect of the Angle ($F(1,28)=17.463$, $p=0.0003$). In both conditions, the mean response time was longer for the difficult angle (0°) than for the easy one, as shown by Table 1 and Fig. 1A.

No other factor yielded a significant effect. Mean response times for simulated grasping with either angle were not significantly different between the two conditions, as shown by the lack of effect of the Condition factor ($F(1,28)=2.08$, $p=0.1604$). This is confirmed by the fact that the main effect of the angle was not significantly dependent from the condition of simulation (1P or 3P) ($F(1,56)=0.408$, $p=0.5283$). Finally, no significant effect was found for the diameter of the dowels ($F(2,28)=0.983$, $p=0.3807$).

2.2. Execution trials

In the execution condition, the difference between mean movement time for simulating the difficult (0°) and the easy (45°) grasping movements was 145 ms (see Table 2).

Table 1 – Mean response times for the 29 participants in the simulation conditions

Control	Exe	
Angle (°)	0	45
Mean RT (ms)	1515.25	1369.3
SD (ms)	303.69	285.75
Mean difference (ms)	145.95	

ANOVA parametrical test with significance set at $p<0.05$ shows a significant result for the factor angle ($F(1,28)=17.463$, $p=0.0003$). RTs for imagined movements with either landmark position are not significantly different between the two conditions ($F(1,28)=2.08$, $p=0.1604$) and the interaction between the two factors – angle and condition (1P,3P) – is not significant ($F(1,56)=0.408$, $p=0.5283$).

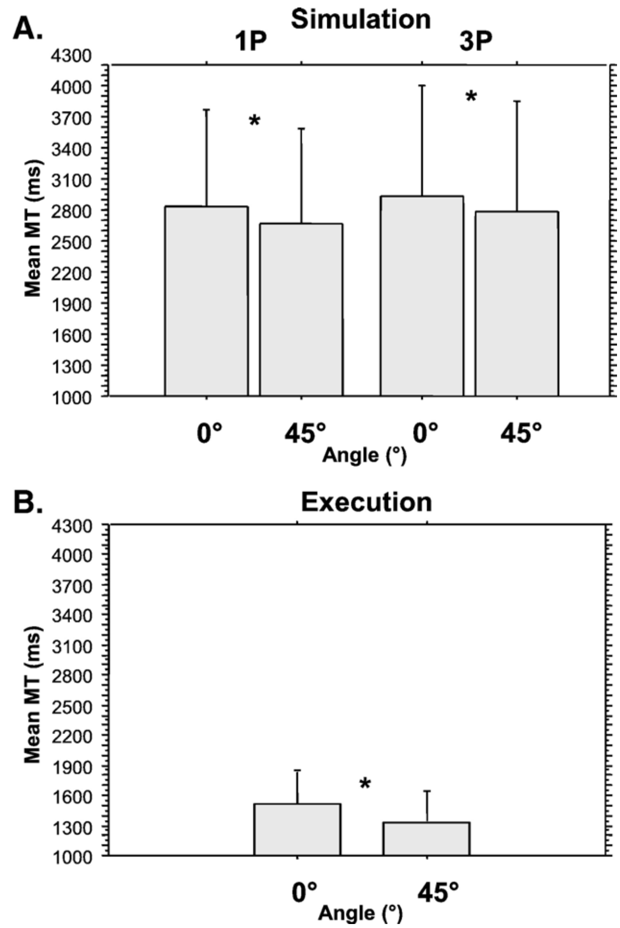

Fig. 1 – Mean results for the execution and simulation experiment. (A) Execution trials. Mean response times and Sd for 0° and 45° oriented grasps. $N=29$. (B) Simulation trials. Mean response times and Sd for the two conditions of mental simulation. 1P: in the first person perspective. 3P in the third person perspective. $N=29$.

A two-sample t-test was used to compare the mean movement times measured during the grasping movement with a 0° angle (mean=1515.25 ms, SD: 303.7) and with a 45° angle (mean=1369.3, SD: 285.7). The difference between the two was found to be significant [$t(29)=11.4$, $p<0.0001$)] (see Fig. 1B).

Note that we did not attempt to statistically compare movement times in execution trials and response times in simulation trials. The reason is that the two measures did not

Table 2 – Mean response times for the 29 participants in the execution condition

Condition	1P		3P	
Angle (°)	0	45	0	45
Mean RT (ms)	2839.5	2663.33	2937.24	2780.22
SD (ms)	922.92	927.42	1069.97	1070.18
Mean difference (ms)	176.156		157.013	

Movement times for 45° are significantly shorter than those for 0°, $t(29)=11.4$, $p<.0001$), with significance set at $p<0.05$.

include the same stages of the motor process. Response time in simulation trials referred to the ensemble of the process beginning with the presentation of the object, whereas movement time in execution trials only referred to the duration of the movement (and indeed, movement times were much shorter than response times).

3. Discussion

In this experiment, we first confirmed that the time it takes a subject to mentally simulate a grasping movement obeys biomechanical constraints to the same extent as actually performed grasping movements: in both conditions, it takes longer to grasp or simulate grasping the cylinders with an opposition axis parallel to the body plane (0°) than with an opposition axis at 45° from the body plane (see Frak et al., 2001). In the execution condition, the longer time needed to perform the difficult trials reflects the processing of the increased dorsiflexion of the wrist and the introduction of an additional degree of freedom (shoulder abduction) which are both required for achieving the task. The fact that the difference also exists in the simulation conditions indicates that this additional time is used at the level of the representation of the action, i.e., that it pertains to the planning stage, and not to the execution stage (Parsons, 1994; Frak et al., 2001; Johnson, 2000). Incidentally, note that this result has an important implication for interpreting the present findings: because the subjects were not aware that the two landmark positions should yield a difference in response times, the fact that a difference was indeed observed rules out the possibility that they were using a conscious strategy.

The novel finding reported here is that the same constraint on response time appears to equally apply whether the subject simulates the grasping action as an agent in the first person perspective, or simulates that same action as performed by another agent facing him. No significant difference could be detected between response times in the two conditions of simulation: the mean response times were similar during simulation in the first person and in the third person perspective, as was the difference in response time between the two orientations of the grasp. A possible interpretation of this result is that the subjects in fact performed the same action from the two perspectives, as if they had mentally rotated themselves so as to superimpose with the virtual subject facing them. Such a change in perspective would have the advantage of preserving the spatial relationship between the acting body and the object and keeping the same set of egocentric coordinates for obtaining the same movement from the new perspective. Note that it is critical that the system of coordinates the observer would use to perform the action corresponds to that of the agent he/she observes. By this way, the laterality of the body parts involved in the observed action can be preserved: this is what distinguishes the observation of an action made by another agent from the observation of a self-generated action seen in a mirror.

This interpretation is in agreement with the current idea that one's own actions and the actions one observes from others are represented in a functionally equivalent way (Rizzolatti et al., 1996; Jeannerod, 2001). Data from the literature strongly support this view. Observation of an action performed by another agent interferes with self-execution of a different action (Kilner et al., 2003; Sebanz et al., 2003); mere observation of effortful actions performed by others triggers changes in the autonomous system (e.g., respiration rate) of the observer (Paccalin and Jeannerod, 2000); the time to awareness of one's own actions is closely similar to the time to awareness of an action that an observed agent is about to perform (Wohlschläger et al., 2003). Experiments testing more directly the motor cortical excitability during executing an action or during first person and third person simulating that action lead to the conclusion that motor cortex is involved to a similar extent in all three conditions (Fadiga et al., 1995, 1999; Strafella and Paus, 2000; Clark et al., 2004). In addition, Maeda et al. (2002) found that the excitability of the motor cortex during watching a moving hand was greater when the hand was presented in a direction pointing away from the body, than in a direction pointing towards the body. In the away condition, it was as if the observer had transposed himself at the position of an agent sitting next to him; in the toward condition, it was as if the observer had rotated himself at the position of an agent facing him. Both spatial transformations are compatible with using the same system of egocentric coordinates and provide a picture of the action as it is seen when executed by another agent.

Finally, neuroimaging experiments clearly suggest that the same neural network is involved during self-generated actions and during the observation of actions performed by others. The outcome of these experiments is twofold. First, they show that the activated zones during action observation, in premotor cortex, primary motor cortex and posterior parietal cortex of the observer (Hamilton et al., 2006), largely overlap those that are activated during preparation and/or simulation of self-generated actions (for review, see Jeannerod, 2006). This overlap is a condition for understanding others' intentions and actions. Second, and critically, they show that this overlap is incomplete. Specific areas are activated in one condition of simulation and not in the others (e.g., Ruby and Decety, 2001; Ramnani and Miall, 2004; Saxe et al., 2006), which is a condition for differentiating self-generated intentions and actions from those of others, and ultimately for attributing them to their authors (Georgieff and Jeannerod, 1998).

The results of the present experiment are in agreement with the first claim, in the sense that the actions simulated from the two perspectives share a common pattern of motor representation, as inferred from their timing. More experiments, however, are needed to fulfill the requirements for the second claim, that is, to disclose the neural basis of the process which accounts for the change in the perspective, from that of an agent to that of an observer.

4. Experimental procedures

4.1. *Participants*

Twenty-nine healthy subjects participated in the study (17 males, 12 females; mean age 32.48 years, SD: 8.06). All subjects were right-handed (Oldfield, 1971) (mean laterality index: 0.810, SD: 0.118). They were naive with respect to the objective of the experiment.

The 29 subjects ran three sessions in a row. They first ran two sessions of simulation trials, and subsequently one session of execution trials. A short training session (less than ten trials) was run prior to the experiment. During this training session, subjects were shown the real dowels and were instructed how to grasp them according to the marks and how to transport them on the spot.

4.2. Simulation trials

4.2.1. Procedure

There were two types of simulation trials: simulation trials from the first person perspective (1P trials) and simulation trials in the perspective of another person sitting in front of them (Third person trials, 3P trials). The 1P trials session was ran first.

During the 1P trials, the subjects were sitting in front of a table. A computer screen was placed on a tabletop at 50 cm from their body plane (see Fig. 2A). They placed their right hand on a response pad placed on the same table at 30 cm from the right side of the screen. The hand was out of sight of the subjects when they fixated the screen. A single trial first involved the presentation of a central fixation point on a blank screen, followed after 500 ms by the presentation of a visual display which was a high-resolution photograph of a display showing plastic cylindrical dowels placed upright on a table, in the sagittal direction and at reaching distance from the subject's body, as well as the image of the spot where the dowel should be placed. The dowels were 7.7 cm high and 3, 4 or 5 cm in diameter. Marks were placed on the dowels, indicating where the subject had to place his/her index and thumb fingertips when imagining grasping the dowel. There were two positions for the marks, which determined two orientations for the opposition axis and corresponded to two levels of difficulty of the task. In the "45°" orientation, the opposition axis was rotated 45° clockwise, which afforded a comfortable grasp with the right hand. In the "0°" orientation, the opposition axis was parallel to the subjects body plane, an orientation which afforded an uncomfortable grasp with an exaggerated dorsiflexion of the wrist. Dowels with different diameters and different mark positions were randomized across trials. Each diameter was presented 16 times and each mark position 24 times (48 trials). A spot appearing to the left of the dowel was also placed on the table, indicating the final position of the dowel. In addition, the image of a right hand in the supine posture was presented in the display at a position on the table corresponding visually to the subject's hand position. Subjects were instructed to imagine moving "their" right hand, grasping the dowel with a finger grip according to the opposition axis defined by the marks, lifting the dowel and finally placing it on the spot. A timer was started at the onset of the visual display and was stopped by the subjects pressing the touch pad when he/she had completed the task.

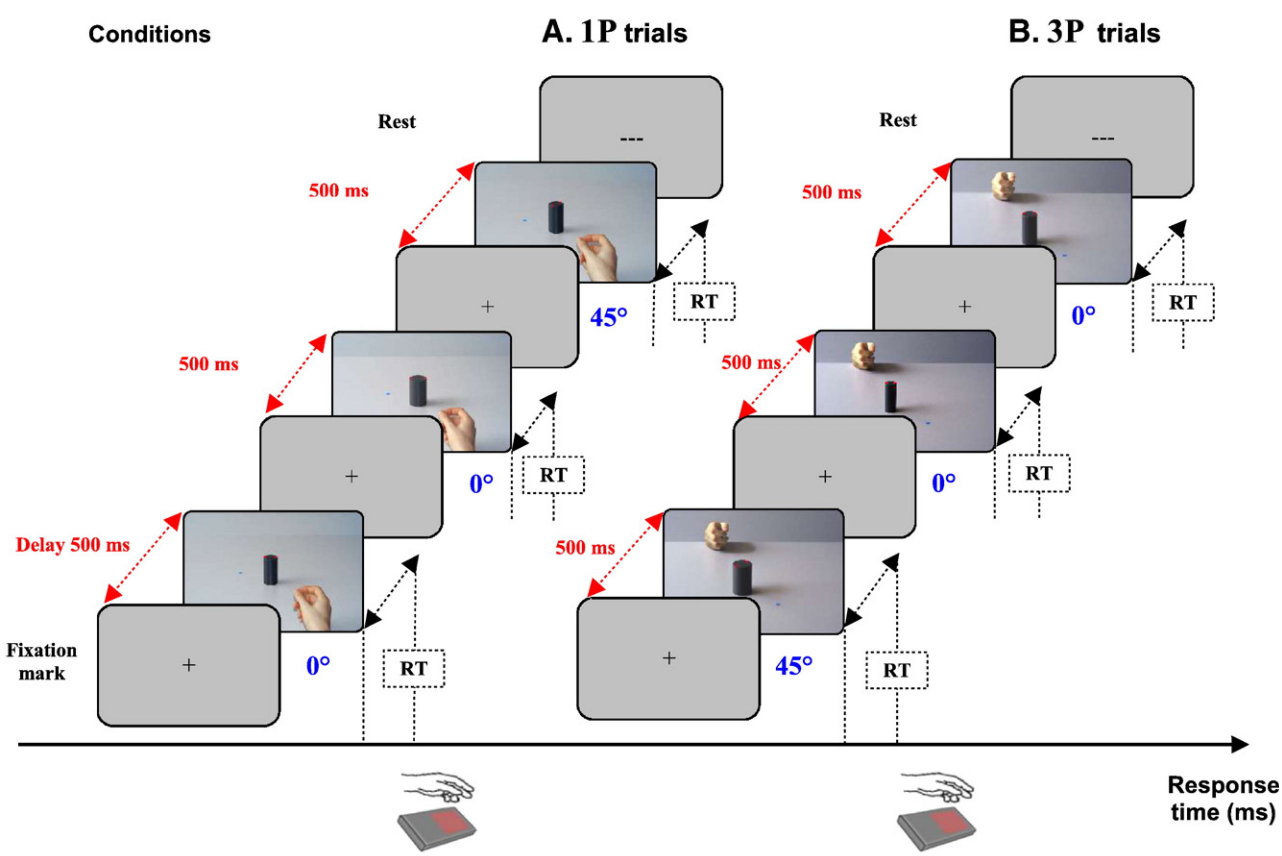

Fig. 2 – Schematic representation of the task used in this study. 1P: first person perspective; 3P: third person perspective.

At the key press, the screen returned blank. The time between presentation of the visual display and the subject's end signal was measured and used as the dependent variable. This time will be referred as the *response time*.

The 3P trials were ran exactly like the 1P trials. The only difference was in the visual display presented on the screen after the fixation point (see Fig. 2B). The dowel and the hand appeared in the display in a symmetrical position with respect to the body plane, i.e., as seen by another person facing the subject. The same number of trials ($N=48$) were run, with the same randomization.

4.2.2. *Data analysis of the simulation trials*

Comparative statistics were computed in a within-subject 2 (conditions: 1P, 3P)×3 (diameter: 3, 4, 5 cm of the cylinders)×2 (angle of orientation of opposition axis: 0°, 45°) repeated measures ANOVA, with the response time (RT in ms) as a continuous dependent variable, using the *Statview* software. The significance was set at $p<0.05$. Trials where response time exceeded±two standard deviations from the mean were excluded from analysis. These trials represented 2.9% of the total number and were distributed throughout the blocks.

4.3. *Execution trials*

During the execution trials, participants were sitting in front of a table where real dowels were displayed at 34 cm from their body plane, along their sagittal axis. The dowels were the same as those shown on the screen in the simulation trials. The subjects had their right hand resting on its cubital edge on the tabletop 15 cm to the right of their body axis. They were instructed to start the reach and grasp movement shortly after a new dowel was displayed on the table. The order of presentation and the number of trials were the same as in the simulation sessions. The task consisted in grasping the dowel near its top by placing the fingers on the marks indicating the orientation of the opposition axis, and to carry it on the spot placed 12 cm to the left. At movement onset, an optical device placed below the hand triggered a timer using the E-prime software. Another optical device stopped the timer at the time where the object was placed on the spot. The time between these two events was measured and was used as the dependent variable for the execution trials. This time will be referred to as *movement time*.

A *t*-test was used to compare the mean movement times for the movements with 45° and 0° angles of orientation. The significance was set at $p<0.05$.

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Corrigendum

Corrigendum to "Simulated actions in the first and in the third person perspectives share common representations" [Brain Res. 1130 (2007) 125–129]

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The authors regret that the data in Tables 1 and 2 are reversed. The corrected Tables 1 and 2 appear here.

Table 1 – Mean response times for the 29 participants in the simulation conditions

Condition	1P		3P	
Angle (deg)	0	45	0	45
Mean RT (ms)	2839.5	2663.33	2957.24	2780.22
SD (ms)	922.92	927.42	1069.97	1070.18
Mean difference (ms)	176.156		157.013	

ANOVA parametrical test with significance set at $p<0.05$ shows a significant result for the factor angle ($F(1,28)=17.463$, $p=0.0003$). RTs for imagined movements with either landmark position are not significantly different between the two conditions ($F(1,28)=2.08$, $p=0.1604$) and the interaction between the two factors – angle and condition (1P, 3P) – is not significantly ($F(1,56)=0.408$, $p=0.5283$).

Table 2 – Mean response times for the 29 participants in the execution conditions

Control	Exe	
Angle (deg)	0	45
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Movement times for 45° are significantly shorter than those for 0°, $t(29)=11.4$, $p<0.0001$), with significance set at $p<0.05$.

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