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Dissociations and similarities in motor intention and motor awareness: the case of anosognosia for hemiplegia and motor neglect

Francesca Garbarini, Alessandro Piedimonte, Manuela Dotta, Lorenzo Pia, Anna Berti

ABSTRACT

Objectives To confront motor awareness in anosognosia for hemiplegia (AHP), where paralyzed patients deny their motor impairment, and in motor neglect (MN), where non-paralyzed patients behave as if they were paretic.

Methods Eight right-brain-damaged patients, 4 hemiplegic (2 with and 2 without AHP) and 4 non-hemiplegic (2 with only perceptual-neglect and 2 with also MN) were evaluated with a bimanual motor battery, before and after examiner’s reinforcement to use the contralesional limb. The requested bimanual movements could be either symmetric or asymmetric, either intransitive or transitive (with/without objects). We compared the examiner’s evaluation of patients’ performance with the patients’ self-evaluation of their own motor capability (explicit knowledge). We also evaluated the presence/absence of compensatory unimanual strategies that, if present, suggests implicit knowledge of the motor deficit.

Results We found significant differences between conditions only in MN patients, whose performance was better after the examiner’s reinforcement than before it, during symmetric than asymmetric movements and during intransitive than transitive movements. As for motor awareness, we found a lack of explicit and implicit knowledge in both AHP and MN patients.

Conclusion Although different in terms of motor intention and motor planning, AHP and MN are both characterised by anosognosia for the motor impairment.

METHODS

Participants We recruited eight right-brain-damaged patients: four hemiplegic patients, two without (HF) and two with anosognosia (AHP); and four patients without hemiplegia, two with only neglect (N) and two with also MN. Neurological/neuropsychological assessment is summarised in online supplementary figure 1A. Patients’ lesion mapping is showed in online supplementary figure 1B.

Experimental task A bimanual motor battery, containing either symmetric or asymmetric, intransitive or transitive (with/without objects) movements (see details in figure 1A), was administrated before and after the examiner’s reinforcement to use the contralesional limb. We evaluated the patients’ ability to perform the bimanual movements with a score ranging from 0 to 2 and we asked the patients a self-evaluation judgement using the same score.
### Bimanual movements list

**Symmetric without objects:**
1. To clap the hands
2. To open/close both hands
3. To lift up both arms
4. To tapping on the table with both index fingers

**Symmetric with objects:**
1. To lift up a tray with both hands
2. To open a cupboard with both hands
3. To grasp two pencils with both hands
4. To reach the examiner’s arms with both hands

**Asymmetric without objects:**
1. To bend one arm while extending the other
2. To touch the table with each hand using alternate rhythm
3. To lift up one arm while moving to the side the other
4. To tap with one index finger while closing the other hand

**Asymmetric with objects:**
1. To open a bottle
2. To close a t-shirt clasp
3. To open an umbrella
4. To tie a knot

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**Figure 1:**
(A) Bimanual motor battery. (B) Examiner’s evaluation of motor neglect (MN) patients’ performance during different experimental conditions of the bimanual motor battery: pre-examiner’s and postexaminer’s reinforcement; asymmetric and symmetric movements; movements with and without object. (C) Crucial contrast between symmetric-with- and symmetric-without-object movements and asymmetric-with- and asymmetric-without-object movements in both pre-examiner and postexaminer’s reinforcement conditions. (D) Comparison between examiner’s evaluation and patient’s self-evaluation: explicit motor unawareness in AHP and MN patients.

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**RESULTS**

In all conditions, both HP and AHP patients received from the examiner the minimum score (0), while N patients the maximum score (2). We found significant differences between conditions only in MN patients. As shown in figure 1B, the MN patients’ performance was better (a) after the examiner’s reinforcement than before it; (b) during symmetric than asymmetric movements; and (c) during ‘without’ than ‘with’ object movements (Wilcoxon test, for each comparison, W(8)=28, Z=2.3, p=0.01). We also found a significant difference between the examiner’s evaluation and the patients’ self-evaluation both within AHP patients (W(8)=36, Z=2.5, p=0.01) and within MN patients (W(6)=21, Z=2.2, p=0.03), suggesting that they both were ‘explicitly’ not aware of the lack of their contralesional movements (see figure 1D).

We also calculated the presence/absence of compensatory unimanual strategies. We only found them in HP patients, suggesting that both AHP and MN patients were also ‘implicitly’ unaware of the lack of their contralesional movements (see table 1).

**DISCUSSION**

Our results showed that, although AHP and MN are dissociated in terms of primary motor capabilities and of motor intention,2 MN patients can be unaware of their motor abnormalities in a similar way as AHP patients. This similarity contributes to make somehow difficult the clinical distinction between the two
syndromes. Here, we propose that the lack of knowledge for motor problems may depend on the impairment at different levels of the chain of motor events described by the computational model of motor control. It is interesting to note that while symmetric-with-object movements improved after the examiner’s reinforcement, asymmetric-with-object movements were the only conditions in which MN patients did not improve their performance. Indeed, before the examiner’s reinforcement, the patients’ performance was significantly worse in symmetric-with-object movements, while, after the examiner’s reinforcement, no difference was found. On the contrary, for the asymmetric movements, before the examiner’s reinforcement there was no difference between with- and without-object movements (patients’ score was low in both conditions) while, after the examiner’s reinforcement, patients’ scores were significantly lower in asymmetric-with- than in asymmetric-without-object movements. It is worth noting that although proximal movements (shoulder) can be mediated by the ipsilateral cortex more than distal movements (fingers), we also described here a specific MN patients’ deficit in intransitive movement was performed better than transitive movements. This might be explained by lesions affecting fronto-parietal circuits underpinning grasping functions. It is interesting to note that, while symmetric-with-object movements improved after the examiner’s reinforcement, asymmetric-with-object movements were the only conditions in which MN patients did not improve their performance. Indeed, before the examiner’s reinforcement, the patients’ performance was significantly worse in symmetric-with- than in symmetric-without-object movements, while, after the examiner’s reinforcement, no difference was found. On the contrary, for the asymmetric movements, before the examiner’s reinforcement there was no difference between with- and without-object movements (patients’ score was low in both conditions) while, after the examiner’s reinforcement, patients’ scores were significantly lower in asymmetric-with- than in asymmetric-without-object movements. It is worth noting that although proximal movements (shoulder) can be mediated by the ipsilateral cortex more than distal movements (fingers), we did not find any difference in proximal versus distal movement execution (both tested in our bimanual battery).

### Table 1: Presence/absence of compensative unimanual strategies: implicit motor unawareness in AHP and MN patients

<table>
<thead>
<tr>
<th>Movement</th>
<th>Compensatory strategy</th>
<th>CS patients</th>
<th>No compensatory strategy</th>
<th>NCS patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>To clap hands</td>
<td>Placing the affected hand open</td>
<td>HPp1; HPp2</td>
<td>Moving only the unaffected hand as if also the affected hand was clapping</td>
<td>AHPp3; AHPp4; MNp7; MNp8</td>
</tr>
<tr>
<td></td>
<td>on the table and clapping with</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>the unaffected one</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To lift up a two-handle</td>
<td>Placing the unaffected hand below</td>
<td>HPp1; HPp2</td>
<td>Grasping one handle with</td>
<td>AHPp3; AHPp4; MNp7; MNp8</td>
</tr>
<tr>
<td>tray</td>
<td>and in the middle of the tray</td>
<td></td>
<td>the unaffected hand as if</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>also the affected hand</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>was grasping the other</td>
<td></td>
</tr>
<tr>
<td>To open a bottle</td>
<td>Placing the bottle between legs</td>
<td>HPp1; HPp2</td>
<td>Holding the top with the</td>
<td>AHPp3; AHPp4; MNp7; MNp8</td>
</tr>
<tr>
<td></td>
<td>and then opening it with the</td>
<td></td>
<td>unaffected hand and then</td>
<td></td>
</tr>
<tr>
<td></td>
<td>the unaffected hand</td>
<td></td>
<td>if the affected hand was</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>holding the bottle</td>
<td></td>
</tr>
<tr>
<td>To close a t-shirt zip</td>
<td>Placing the t-shirt extremity between</td>
<td>HPp1; HPp2</td>
<td>Trying to close the zip</td>
<td>AHPp3; AHPp4; MNp7; MNp8</td>
</tr>
<tr>
<td></td>
<td>legs and then close the zip with the</td>
<td></td>
<td>with the unaffected hand</td>
<td></td>
</tr>
<tr>
<td></td>
<td>the unaffected hand</td>
<td></td>
<td>as if the affected hand</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>was holding the handle</td>
<td></td>
</tr>
<tr>
<td>To open an umbrella</td>
<td>Placing the handle between legs</td>
<td>HPp1; HPp2</td>
<td>Trying to open the</td>
<td>AHPp3; AHPp4; MNp7; MNp8</td>
</tr>
<tr>
<td></td>
<td>and then opening the umbrella with</td>
<td></td>
<td>umbrella with the</td>
<td></td>
</tr>
<tr>
<td></td>
<td>the unaffected hand</td>
<td></td>
<td>unaffected hand as if</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>the affected hand had</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>was holding the handle</td>
<td></td>
</tr>
<tr>
<td>To tie a knot</td>
<td>Placing the string on the table and</td>
<td>HPp1; HPp2</td>
<td>Holding one end of the</td>
<td>AHPp3; AHPp4; MNp7; MNp8</td>
</tr>
<tr>
<td></td>
<td>tying a knot using only the unaffected hand</td>
<td></td>
<td>string with the</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>unaffected hand and trying</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>to tie a knot as if the</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>affected hand was holding</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>the other end</td>
<td></td>
</tr>
</tbody>
</table>

Neglect patients were not included because they actually performed all bimanual movements proposed (in each condition score = 2). Only six out of 16 bimanual movements have been considered: for the other 10, alternative unimanual strategies were not possible.

AHP, anosognosia for hemiplegia; CS, compensatory strategy; MN, motor neglect; NCS, no compensatory strategy.
Finally, our study may also provide some helpful hints for rehabilitation of MN patients’ motor disability indicating the importance of focusing patients’ attention on motor awareness through verbal reinforcement and by means of bimanual symmetric movements which, being preserved in MN patients, may help in recovering contralesional motor functions.

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Contributors FG, AP and AB designed the study. LP conducted patients’ lesion mapping. FG and MD selected the patients, gathered behavioural data and collected the instrumental data. AP and FG conducted statistical analysis. FG, AP, LP and AB interpreted the data. FG and AB wrote the paper. All authors reviewed the first draft of the paper.

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