Imaging in Disorders of Self-Consciousness

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Reducing consciousness to 2D

Laureys, Trends in Cognitive Sciences, 2005
Laureys et al, Nature Clinical Medicine, 2008
Consciousness ≠ global brain function

Laureys et al., *Lancet Neurology*, 2004
Consciousness \approx \text{network functioning}

Areas systematically dysfunctional in "vegetative" state & recovering activity after recovery of consciousness

Precuneus seems a critical hub

Laureys et al, \textit{Neuroimage} 1999
Laureys et al, \textit{J Neurol Neurosurg Psychiatry}, 1999
Laureys et al, \textit{Lancet Neurology}, 2004
Two awareness networks

EXTERNAL or SENSORY AWARENESS

INTERNAL or SELF AWARENESS

→ Default Mode Network

Laureys, Scientific American 2007
Vanhaudenhuyse, Demertzi et al, J Cogn Neurosci 2011
Diagnostic error **after** coma

103 post-comatose patients
- 45 clinical consensus diagnosis ‘vegetative state’
- 18 showed signs of awareness

40% potential misdiagnosis

Solution: Coma Recovery Scale Revised (CRS-R)

Limitations of the CRS-R:
- Patients suffering from aphasia or lack of motivation on of the patient
- Motor abilities

Schnakers et al, *BMC Neurology* 2009
Resting connectivity: fMRI

Vanhaudenhuyse et al, *Brain* 2010
Demertzi et al, *Brain*, in press

Precuneus connectivity was found to be significantly stronger in MCS as compared with VS/UWS.
Resting state metabolism: FDG-PET

### Coma Recovery Scale - Revised results

<table>
<thead>
<tr>
<th></th>
<th>UWS</th>
<th>MCS</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clinical consensus diagnosis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VS/UWS</td>
<td>33</td>
<td>18</td>
<td>51</td>
</tr>
<tr>
<td>MCS</td>
<td>2</td>
<td>36</td>
<td>38</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
<td>54</td>
<td>89</td>
</tr>
<tr>
<td><strong>18F-FDG PET</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VS/UWS</td>
<td>24</td>
<td>5</td>
<td>29</td>
</tr>
<tr>
<td>MCS</td>
<td>12</td>
<td>71</td>
<td>83</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td>76</td>
<td>112</td>
</tr>
<tr>
<td><strong>Mental imagery fMRI</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VS/UWS</td>
<td>25</td>
<td>23</td>
<td>48</td>
</tr>
<tr>
<td>MCS</td>
<td>3</td>
<td>19</td>
<td>22</td>
</tr>
<tr>
<td>Total</td>
<td>28</td>
<td>42</td>
<td>70</td>
</tr>
</tbody>
</table>

**UWS** = unresponsive wakefulness syndrome. **MCS** = minimally conscious state.

**Table 2: Diagnostic results by modality**

- 35% clinical misdiagnosis
- 32% CRS-R misdiagnosis

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Stender & Gossières... Laureys, *Lancet* 2014
fMRI-based communication

Monti & Vanhaudenhuyse, Coleman, Boly, Pickard, Tshibanda, Owen, Laureys
New England J Med 2010

www.comascience.org
EEG-based communication

3/16 VS/UWS (19%)

Cruse et al, *Neurology* 2012
7/23 MCS (30%)

also see Goldfine et al, *Lancet* 2013
Prognosis: MRI - DTI

Galanaud et al, Anesthesiology, 2012
Luyt et al, Anesthesiology, 2012
Pain in UWS and MCS

MCS patients activate the same areas as healthy controls, meaning that the stimulus can be integrated and processed.

Stimulation: Frontal cortex (tDCS)

Transcranial Direct Current Stimulation (tDCS)

the left dorsolateral prefrontal

Thibaut et al, Neurology 2014
Conclusion

Human conscious awareness
≈ emergent property of collective critical neural network dynamics

Awareness can be subdivided into internal and external awareness supported by different networks

Diagnosis
CRS-R as gold standard
Neuroimaging
Neurophysiology

Laureys & Schiff, *NeuroImage*, 2012