Consciousness and disorders of consciousness

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www.comascience.org
Overview

Consciousness
Short history of coma
Scientific interest
Clinical interest
Conclusion

Terry Schiavo °1963, vegetative 1990, † 2005

« Irreversible loss of the capacity for consciousness and social interaction equals death »
- Robert Veatch, 1975

« Should organs from patients in permanent vegetative state be used for transplantation? »
- Hoffenberg, Lancet 1997

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Reducing consciousness to 2D

Laureys, Trends in Cognitive Sciences, 2005
Short history of coma
Artificial respirator (1952)
Coma dépassé (1959)

After four years of reflection, we choose to propose a method of approaching the concept of coma.

It should be noted that the problem of coma appeared to be obsolete, the work described in progresses of the International Society of Neurology of the Hospital Chaude-Berard of 7 October 1956, at a time the main points of criticism are:

The present communication, which was a prelude to a preliminary paper, was the subject of a presentation at the XXVIIth Session of the International Society of Neurology, which has accepted the second of its sessions in the Centre de Neuroradiologie and has dedicated sessions to this work. The presentation was that the coma had no right whatever to exist in the International Society, which voiced the efforts of M. Pacheco and P. Mallin (translation, not at all)

We refer to our authors and figures of our recent work to further understand the present article and its context. Some important points are:

- www.comascience.org
- Consciousness | History | Scientific | Clinical | Conclusion
Definition of brain death

Harvard Committee 1968

Wijdicks, NEJM 2001

Bueri et al Mov Disord. 2000, 15:583-6
Scientific interest
Consciousness ≠ whole brain

Laureys et al, Lancet Neurology, 2004

www.comascience.org
Consciousness ≈ frontoparietal

areas that are systematically dysfunctional in the vegetative state

areas that recover metabolism after recovery from the vegetative state

Laureys et al, Neuroimage 1999

Laureys et al, J Neurol Neurosurg Psychiatry, 1999
Precuneus ≈ hub in the network

Conscious controls (n=110)  Vegetative state (n=33)
Locked in syndrome (n=5)  Minimally conscious state (n=7)

Laureys et al, Lancet Neurology, 2004

Axonal re-growth in Terry Wallis

Voss et al, J Clin Invest, 2006
Precuneus ≈ hub in the network

- **SLEEP**
  - Activity in PCC/precuneus

- **ANESTHESIA**
  - Activity in PCC/precuneus

Global workspace theory

Dehaene et al, Trends in Cognitive Sciences 2006

www.comascience.org
Consciousness ≈ thalamo-cortical

Intralaminar nuclei “reconnections” in spontaneous recovery from the vegetative state

Intralaminar nuclei stimulation induces “recovery” from the minimally conscious state

Laureys et al, Lancet 2000

Schiff et al., Nature 2007
Clinical interest
Disorders of consciousness

Laureys, *Scientific American* 2007

1952, artificial respirator (Ibsen, Copenhagen)
Redefinition of death based on neurological criteria

1966, Plum & Posner (NY)
Locked-In Syndrome

1972, Jennett (Glasgow) & Plum (NY)
Vegetative State

1994, Multi-Society Task Force on PVS
>1 year (traumatic)
>3 months (non-traumatic; anoxic)

1994, Multi-Society Task Force on PVS
Permanent Vegetative State

2002, Aspen Workgroup
Minimally Conscious State

Recovery of Consciousness

Permanent Minimally Conscious State

Fast Recovery

Acute Brain Injury

Coma

Brain Death
Diagnosis
Assessing consciousness

**COGNITIVE CAPACITY**

- **MOTOR RESPONSIVENESS**
  - **VS** (vegetative state)
  - **MCS** (minimal conscious state)
  - **comatose state**

**CONCLUSION**

- live independently
- professional reinsertion
- good recovery
- moderate disability
- severe disability
- communication
- awareness
- arousal

Consensus | History | Scientific | Clinical | Conclusion
Misdiagnosis of vegetative state

n=103 post-comatose patients

45 clinical consensus diagnosis ‘vegetative state’
18 signs of awareness (Coma Recovery Scale)

40% potential misdiagnoses

Schnakers et al, *BMC Neurology* 2009
Coma recovery scale

<table>
<thead>
<tr>
<th>Patient</th>
<th>Date admission</th>
<th>Examinateur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis initial</td>
<td>Date</td>
<td></td>
</tr>
</tbody>
</table>

**FONCTION AUDITIVE**
- 4: Movement systematic on demand
- 3: Movement reproducible on demand
- 2: Localisation of sound
- 1: Reflex of ear to sound
- 0: Néant

**FONCTION VISUELLE**
- 6: Recognition of object:
- 5: Object recognition
- 4: Pupil size
- 3: Fixation
- 2: Reflex of eye to menace
- 0: Néant

**FONCTION MOTRICE**
- 9: Use of objects
- 8: Haptic movements
- 7: Manipulation
- 6: Fixation
- 5: Posture abnormal
- 4: Tone absence

**FONCTION MOTRICE VERBALE**
- 9: Production intelligible
- 8: Production oral
- 7: Movement orals
- 6: Reflex orals
- 5: Néant

**COMMUNICATION**
- 9: Functionality expressive
- 8: Non-functional: non-expression
- 7: Néant

**EVOL**
- 3: Attention
- 2: Opening of eyes without stimulation
- 1: Opening of eyes with stimulation
- 0:澳onnal évènement

**SCORE TOTAL**

Schnakers et al Brain Injury 2008

www.comascience.org
Eye tracking: use a mirror!

![Graph showing number of MCS patients tracking different objects.](image)

- **Legend**
  - Mirror
  - Person
  - Object

**Statistics**
- n=52

**References**
- Vanhaudenhuyse et al. 
  *J Neurol Neurosurg Psychiatry* 2008
Signs of consciousness on fMRI


www.comascience.org
≠ “automatic” brain response

Soddu et al, Prog Brain Res 2009
Yes-No communication with fMRI

Monti & Vanhaudenhuyse, Coleman, Boly, Pickard, Tshibanda, Owen, Laureys
New England J Med 2010
<table>
<thead>
<tr>
<th>response option</th>
<th>encoding parameters</th>
<th>single-trial time courses and RTCs</th>
<th>ranking (correlation)</th>
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<tbody>
<tr>
<td>A</td>
<td>brain location 'motor imagery' ROI onset 0s offset 10s</td>
<td>[Graph of MRI response]</td>
<td>1st (0.89)</td>
</tr>
<tr>
<td>B</td>
<td>brain location 'mental calculation' ROI onset 5s offset 10s</td>
<td>[Graph of MRI response]</td>
<td>2nd (0.52)</td>
</tr>
<tr>
<td>C</td>
<td>brain location 'motor imagery' ROI onset 5s offset 15s</td>
<td>[Graph of MRI response]</td>
<td>3rd (0.06)</td>
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<td>D</td>
<td>brain location 'mental calculation' ROI onset 10s offset 20s</td>
<td>[Graph of MRI response]</td>
<td>4th (-0.20)</td>
</tr>
</tbody>
</table>

Sorger et al, Prog Brain Res 2009

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Coma or total locked-in syndrome?
21-y old woman
basilar artery thrombosis - day 49

Other names PASSIVE
Count TARGET (other name)
Own name PASSIVE
Count TARGET (own name)

Schnakers et al, Neurology, 2008
Schnakers et al, Neurocase, 2009
Conclusion
Neural correlates of conscious awareness
≈ emergent property of the collective behavior
  of fronto-parietal neuronal ‘global workspace’
≈ cortico-thalamo-cortical functional connectivity

Diagnostic use
≈ 40% signs of consciousness in vegetative state
THANK YOU
slides can be downloaded on website
EU funded positions open

PhD candidates:
- Marie-Aurélie Bruno
- Olivia Gossseries
- Athena Demertzi
- Camille Chatelle
- Marie Thonnard
- Victor Cologan
- Jean-Floris Tshibanda MD
- Pierre Boveroux MD
- Muriel Kirsch MD
- Audrey Maudoux MD
- Isabelle Lutte MD

PhDs:
- Audrey Vanhaudenhuyse
- Melanie Boly MD
- Didier Ledoux MD
- Caroline Schnakers
- Quentin Noirhomme Engineering
- Andrea Soddu Physics
- Betina Sorger Maastricht
- Dorothée Lulé Tubingen

Collaborations:
- NY N Schiff, J Fins, J Giacino
- Cambridge A Owen et al
- Milano M Massimini et al
- Wisconsin G Tononi et al
- Tubingen & Wurzburg A Kübler
- Paris L Puybasset et al
- Hangzhou China H Di
- Salzburg M Schabus
- Lyon F Perrin
- Weizmann R Malach et al
- Naples M Papa

Visiting fellows:
- Natalia Lapitskaia, Remy Lehembre, Jonathan Orban, Francisco Gomez...