Exploration of consciousness: Disorders of consciousness & near-death experiences

Charlène AUBINET
Neuropsychologist & Speech therapist
PhD Student

Charlotte MARTIAL
Neuropsychologist
PhD Student

GIGA Consciousness
University of Liège, Belgium

13th June 2016
Academic career

• Charlène Aubinet
  – Master in clinical neuropsychology
  – Master in speech therapy
  – Language neuropsychology
  – PhD student – 1st year

• Charlotte Martial
  – Master in psychology
  – Neuroscience
  – PhD student – 2nd year
  – FNRS grant

Pr Steven Laureys
PART 1
Disorders of consciousness & language impairment

• Definition of consciousness
• Coma recovery
• Diagnosis of disorders of consciousness (DOC)
• Language comprehension impairment in DOC patients

PART 2
Near-Death Experience

• What is a Near-Death Experience (NDE)?
• Characteristics of NDEs memories
• Cognitive characteristics of NDE experiencers
• Reproducing NDEs
PART 1:
Disorders of consciousness & language impairment

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How to define « consciousness »?
Reducing consciousness in 2D

Laureys, Trends in Cognitive Sciences, 2005
Laureys et al, Nature Clinical Medicine, 2008
Possible causes of coma

PART 1: Definition – DOC – Diagnosis – Language

- Aggression
- Hypoglycemia
- Hypothermia
- Hemorrhage
- Car Accident
- Stroke
- Cerebral hypoxia
- Encephalopathy
- Intoxication
How do patients in coma (partially) recover consciousness?
Consciousness is spread on a continuum

Vanhaudenhuyse, Boly, Laureys. Scholarpedia (2009)
Disorders of consciousness

PART 1: Definition – DOC – Diagnosis – Language

~ Vegetative state

- Partially preserved sleep-wake cycles
- Absence of purposeful behaviors
- Absence of language
- Preserved hypothalamic and brainstem autonomic functions

Multi-Society Task Force on Persistent Vegetative State guidelines, 1994; Laureys et al., BMC Med, 2010
Disorders of consciousness

Giacino et al., Neurology, 2002
Disorders of consciousness

PART 1: Definition – DOC – Diagnosis – Language

- Eyes **always** closed
- Duration: > 1h
- Recovery from coma: few hours to 4 weeks

Disorders of consciousness

Coma
Unresponsive wakefulness syndrome
Minimally conscious state
Emergence of minimally conscious state

- Eye opening
- Preserved sleep-wake cycles
- Clear signs of reproducible purposeful behaviors
- Emotionally contingent behaviors
- Challenge: fluctuation +++

Clinical subcategorization of MCS patients

MCS -
- Oriented (contextualized) behaviors
- Visual pursuit or fixation
- Orientation to noxious stimulation
- Reaching for objects
- Contingent behaviors (emotional)

MCS +
- Following simple commands
- Intentional communication
- Intelligible verbalization

MCS- < MCS+

Bruno, Vanhaudenhuyse et al., J Neurol, 2011; Bruno et al., J Neurol, 2012
How to diagnose patients with DOC?
1. Behavioral assessments

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
- When using only 1 CRS-R assessment ~ 34% chance of false negatives
  ⇒ Perform at least 5 assessments

Schnakers et al, BMC Neurology 2009; Wannez & al., submitted
2. Neuroimaging

Spontaneous activity
PET/fMRI/EEG to measure spontaneous, stimulus-independent activity

Passive paradigms
fMRI/EEG to measure stimulus-induced activity

Active paradigms
EEG/fMRI to measure command-related activity
2. Neuroimaging - Spontaneous activity

Magnetic Resonance Imagery (MRI) vs. Positon Emission Tomography (PET)

MCS > VS/UWS

Precuneus connectivity & metabolism

Vanhaudenhuyse et al, *Brain* 2010

Consciousness ≠ global brain function

Laureys et al., Lancet Neurology, 2004
Two awareness networks

2. Neuroimaging – Passive paradigm
2. Neuroimaging – Active paradigm

3. Brain Computer Interfaces

Allows a communication system between a computer and a person without the need of muscular intervention.
3. Brain Computer Interfaces

- **MindBeagle**

  - Assessment of awareness
    - P300 auditory oddball paradigm
  - Assessment of command following
    - P300 vibrotactile oddball paradigm
  - Communication
    - Motor imagery


MindBeagle by Gtec, Graz, Austria

Cruse et al., *Lancet* 2012 & Cruse et al., *Neurology* 2012
How to know that DOC patients understand language?
1. Bedside assessment

**MCS LANGUAGE COMPREHENSION TEST**
Administration Guidelines

**Administration:**
- Choose two (2) non-object related commands to be administered across the three first subtests (A" to "C") and two (2) object-related commands to be administered across the three last subtests ("D" to "F"), in the command list set below. For the non-object related commands, choose one non-limb related command and one limb related command.
- In each subtest, each command is presented on 4 occasions (i.e., 4 trials) with an interval of time of 10 seconds between each trial.
- Each command has two levels of complexity, with Level 1 commands to be administered only in the event of Level 2 task failure (i.e., less than 3 of 4 trials succeeded) within individual subtests.
- For all subtests, stand direct in front of patient in a quiet environment. Provided arousal facilitation via deep pressure stimulation if applicable at any point during test administration.

**Command List Set:**

<table>
<thead>
<tr>
<th>Non-Object Related Commands: Pick two (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level 2</strong></td>
</tr>
<tr>
<td><strong>Level 1</strong></td>
</tr>
<tr>
<td>Non-limb Movement</td>
</tr>
<tr>
<td>Show me how you close your eyes.</td>
</tr>
<tr>
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**Scoring Instructions:**
Score responses noted across subtests, as follows:
- 3 Points: Accurate to **Level 2 commands** (Motor movement accurately matches command on at least 3 out of 4 trials)
- 2 Points: Accurate to **Level 1 commands** (Motor movement accurately matches command on at least 3 out of 4 trials)
- 1 Point: Inaccurate to both **Level 2 & 1** (Motor movement does not match command)
- 0 Points: No response to both **Level 2 & 1**

- **24 post-stroke aphasic but conscious patients**
  - Complex vs simple commands
  - Oral vs written commands
  - Gestural cueing vs no gesture
Bedside assessment

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24 post-stroke aphasic but conscious patients
- Complex vs simple commands

Aubinet, C. & al (in preparation)
PART 1: Definition – DOC – Diagnosis – Language

Bedside assessment

- 24 post-stroke aphasic but conscious patients
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  - Oral vs written commands

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Aubinet, C. & al (in preparation)
Bedside assessment

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Aubinet, C. & al (in preparation)
2. Neuroimaging

- **PET resting state study**
  - Metabolic impairment in a bilateral subcortical (thalamus and caudate) and cortical (fronto-temporo-parietal) network in MCS patients.
  - Compared to MCS-, MCS+ showed preserved cerebral metabolism in left-sided cortical areas.

- **fMRI resting state study**
  - Left fronto-parietal connectivity:
    - Controls > MCS+ > MCS-
    - This language network is more connected in MCS+ to the left temporo-occipital fusiform cortex.
    - It is part of a “language associations area” mainly dedicated to comprehension abilities.

Bruno & al. (2012); Aubinet, C. & al. (in preparation)
2. Neuroimaging

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Aubinet, C. & al (in preparation)
PART 2: Near-Death Experience (NDE)

Charlotte MARTIAL
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What is a Near-Death Experience (NDE)?

- **NDE** = memories reported by some individuals who had recovered consciousness after coma

- No consensus on NDE definition!

- BUT propositions:
  NDEs = “profound psychological events with transcendental and mystical elements typically occurring to individuals close to death or in situations of intense physical or emotional danger”

- Decreased of brain activity, but not stopped!

Greyson, 2000; Charland-Verville et al., 2014
What is a Near-Death Experience (NDE)?

‘Out-of-Body Experience’ (OBE)  \[\rightarrow\text{temporo-parietal junction}\]

Seeing a bright light  \[\rightarrow\text{occipital lobe}\]
Seeing a tunnel
Encounter with spirits
Harmony
**What is a Near-Death Experience (NDE)?**

**Greyson NDE scale:** Scores $\geq 7 = $ NDE experiencer

<table>
<thead>
<tr>
<th>Cognitive</th>
<th>Affective</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Did time seem to speed up or slow down?</td>
<td>(5) Did you have a feeling of peace or pleasantness?</td>
</tr>
<tr>
<td>0 = No</td>
<td>0 = No</td>
</tr>
<tr>
<td>1 = Time seemed to go faster or slower than usual</td>
<td>1 = Relief or calmness</td>
</tr>
<tr>
<td>2 = Everything seemed to be happening at once; or time stopped or lost all meaning</td>
<td>2 = Incredible peace or pleasantness</td>
</tr>
<tr>
<td>(2) Were your thoughts speeded up?</td>
<td>(6) Did you have a feeling of joy?</td>
</tr>
<tr>
<td>0 = No</td>
<td>0 = No</td>
</tr>
<tr>
<td>1 = Faster than usual</td>
<td>1 = Happiness</td>
</tr>
<tr>
<td>2 = Incredibly fast</td>
<td>2 = Incredible joy</td>
</tr>
<tr>
<td>(3) Did scenes from your past come back to you?</td>
<td>(7) Did you feel a sense of harmony or unity with the universe?</td>
</tr>
<tr>
<td>0 = No</td>
<td>0 = No</td>
</tr>
<tr>
<td>1 = I remembered many past events</td>
<td>1 = I felt no longer in conflict with nature</td>
</tr>
<tr>
<td>2 = My past flashed before me, out of my control</td>
<td>2 = I felt united or one with the world</td>
</tr>
<tr>
<td>(4) Did you suddenly seem to understand everything?</td>
<td>(8) Did you see, or feel surrounded by, a brilliant light?</td>
</tr>
<tr>
<td>0 = No</td>
<td>0 = No</td>
</tr>
<tr>
<td>1 = Everything about myself or others</td>
<td>1 = An unusually bright light</td>
</tr>
<tr>
<td>2 = Everything about the universe</td>
<td>2 = A light clearly of mystical or other-worldly origin</td>
</tr>
</tbody>
</table>

Greyson, 1983
What is a Near-Death Experience (NDE)?

**Greyson NDE scale:** Scores ≥7 = NDE experiencer

**Paranormal**

(9) Were your senses more vivid than usual?
- 0 = No
- 1 = More vivid than usual
- 2 = Incredibly more vivid

(10) Did you seem to be aware of things going on elsewhere, as if by ESP?
- 0 = No
- 1 = Yes, but the facts have not been checked out
- 2 = Yes, and the facts have been checked out

(11) Did scenes from the future come to you?
- 0 = No
- 1 = Scenes from my personal future
- 2 = Scenes from the world's future

(12) Did you feel separated from your body?
- 0 = No
- 1 = I lost awareness of my body
- 2 = I clearly left my body and existed out

**Transcendental**

(13) Did you seem to enter some other, unearthly world?
- 0 = No
- 1 = Some unfamiliar and strange place
- 2 = A clearly mystical or unearthly realm

(14) Did you seem to encounter a mystical being or presence, or hear an unidentifiable voice?
- 0 = No
- 1 = I heard a voice I could not identify
- 2 = I encountered a definite being, or a voice clearly of mystical or unearthly origin

(15) Did you see deceased or religious spirits?
- 0 = No
- 1 = I sensed their presence
- 2 = I actually saw them

(16) Did you come to a border or point of no return?
- 0 = No
- 1 = I came to a definite conscious decision to return to life
- 2 = I came to a barrier that I was not permitted to cross; or was sent back against my will

Greyson, 1983
What is a Near-Death Experience (NDE)?

Charland et al., 2014

**Greyson NDE scale features frequencies (%)**

- Peacefulness
- Out-of-Body experience
- Bright light
- Altered time perception
- Unearthly environment
- Happiness/joy
- Harmony/unity
- Border
- Heightened senses
- Understanding
- Presence
- Speeded thoughts
- Encounters
- Extrasensory perception
- Precognitive visions
- Life review

<table>
<thead>
<tr>
<th>Feature</th>
<th>Life-threatening “Real NDEs” n=140</th>
<th>Non-life-threatening “NDE-like” n=50</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total score 16 ± 6 (7-30/32)</td>
<td>Total score 17 ± 7 (7-30/32)</td>
</tr>
<tr>
<td>Anoxia</td>
<td>15 ± 6 (7-29)</td>
<td></td>
</tr>
<tr>
<td>Trauma</td>
<td>16 ± 6 (7-26)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>16 ± 6 (7-30)</td>
<td></td>
</tr>
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</table>
Characteristics of NDEs memories

Memory Characteristics Questionnaire (MCQ; Johnson et al., 1988) total scores for each assessed memory

-> NDE memory

Thonnard & Charland et al., 2013
## Characteristics of NDEs memories

<table>
<thead>
<tr>
<th></th>
<th>Greyson total score</th>
<th>MCQ total score</th>
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</thead>
<tbody>
<tr>
<td><strong>Demography</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at interview</td>
<td>-.11 (.167)</td>
<td>.007 (.925)</td>
</tr>
<tr>
<td>Age at NDE</td>
<td>-.14 (.079)</td>
<td>.009 (.911)</td>
</tr>
<tr>
<td>Time since NDE</td>
<td>.06 (.448)</td>
<td>-.001 (.984)</td>
</tr>
<tr>
<td><strong>Greyson total score</strong></td>
<td>-</td>
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Data are Pearson's correlations ($\rho$).

NDE experiencers who described more intense NDEs also reported more phenomenological characteristics of NDE.
Cognitive characteristics of NDE experiencers

From the experiencer’s point of view:

- **NDE memories**
  → a sense of *“phenomenological certainty”*  
  (Dell'Olio, 2010)

  → seem unrivalled memories due to its associated rich phenomenology  
  (Thonnard & Charland-Verville et al., 2013)

  … while we do not have any certainty that this experience was lived in reality!

- Investigation of false memory susceptibility
Cognitive characteristics of NDE experiencers

• Using the DRM paradigm

(Deese, 1959; Roediger & McDermott, 1995)

- Braveness
- Persistency
- Daring
- Assurance
- Foolhardiness
- Valiance
- Tenacity
- Audacity
- Boldness
- Ardour
- Will
- Determination

Courage

• NDE experiencers group VS control subjects group

Martial et al., submitted
Cognitive characteristics of NDE experiencers

Mean proportions of false memories & studied words recalled with certainty at free recall test in NDErs and matched volunteers.

![Graph showing mean proportions of false memories and studied words recalled with certainty in NDErs and matched volunteers.](image-url)
Reproducing NDEs

- Reproducing NDEs in controlled laboratory setting, by inducing hypoxic loss of consciousness produces NDE like memories

- Identified NDE experiencers: 9/26 (35%)

Charland-Verville et al., submitted
Any questions?

www.comascience.org
THANKS FOR YOUR ATTENTION

caubinet@ulg.be
cmartial@ulg.ac.be
coma@ulg.ac.be