Brain, behavior and cognitive interplay in disorders of consciousness: A multiple case study

BAPS meeting
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UGent

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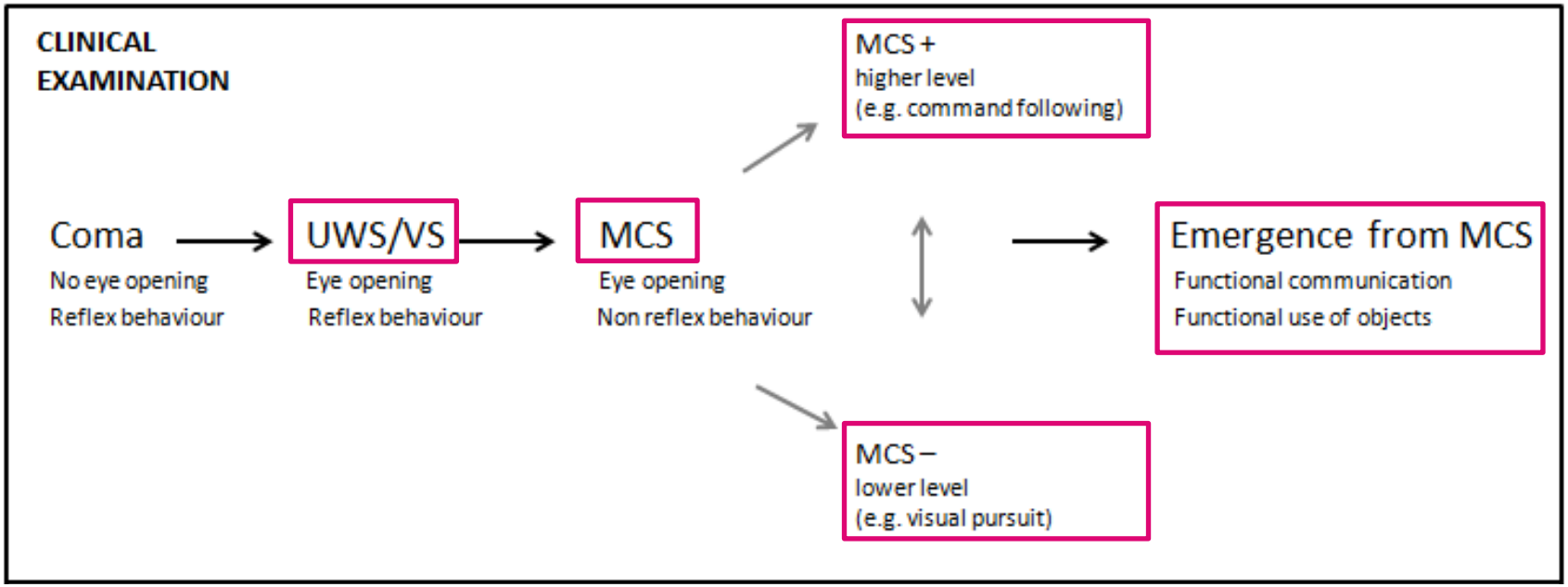
1. Introduction

Altered states of consciousness and diagnostic issues



n=126 post-comatose patients

Clinical consensus diagnosis:

- 51 'vegetative state'
- 18 signs of awareness

Coma Recovery Scale - Revised

↳ **30-40% potential misdiagnosis**

Bodart, Gosseries & Laureys, *Semin Neurol*, 2013
Schnakers et al, *BMC Neurology*, 2009
Stender & Gosseries et al, *Lancet*, 2014

Aims of the study

1) To study the behavioral, cognitive and neuroimaging profile of 5 different patients in MCS and EMCS

→Hypothesis: association between patients' structural and functional brain damage and their behavioral/cognitive profile, consistent with previous studies establishing neural correlates of behavior, language and cognition.

2) To highlight the importance to develop new assessment tools to refine the cognitive profile of post-comatose patients

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2. Material and method

Coma Recovery Scale-Revised

(CRS-R; Giacino & al, 2004)

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JFK COMA RECOVERY SCALE - REVISED ©2004

Record Form

Patient: Date:								
AUDITORY FUNCTION SCALE								
4 - Consistent Movement to Command *								
3 - Reproducible Movement to Command *								
2 - Localization to Sound								
1 - Auditory Startle								
0 - None								
VISUAL FUNCTION SCALE								
5 - Object Recognition *								
4 - Object Localization: Reaching *								
3 - Visual Pursuit *								
2 - Fixation *								
1 - Visual Startle								
0 - None								
MOTOR FUNCTION SCALE								
6 - Functional Object Use †								
5 - Automatic Motor Response *								
4 - Object Manipulation *								
3 - Localization to Noxious Stimulation *								
2 - Flexion Withdrawal								
1 - Abnormal Posturing								
0 - None/Flaccid								
OROMOTOR/VERBAL FUNCTION SCALE								
3 - Intelligible Verbalization *								
2 - Vocalization/Oral Movement								
1 - Oral Reflexive Movement								
0 - None								
COMMUNICATION SCALE								
2 - Functional: Accurate †								
1 - Non-Functional: Intentional *								
0 - None								
AROUSAL SCALE								
3 - Attention								
2 - Eye Opening w/o Stimulation								
1 - Eye Opening with Stimulation								
0 - Unarousable								
TOTAL SCORE								

Cognitive Assessment by Visual Election

(CAVE; Murphy, 2018)

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- *Cognitive Assessment by Visual Election*

  (CAVE; Murphy, 2018)

Cut-off score = 8/10

COGNITIVE ASSESSMENT BY VISUAL ELECTION

NAME: ..... DATE .....

A. REAL OBJECTS			
1. Ball		BUS	
2. CUP		Comb	
3. Cow		PIG	
4. Bus		CAR	
5. PEN		Fork	
6. Car		COW	
7. SPOON		Cup	
8. COMB		Pen	
9. FORK		Spoon	
10. Pig		BALL	
Total Left:		Right:	
Grand total:			
Pass/Fail:			

B. NUMBERS			
1. 5		8	
2. 3		9	
3. 1		7	
4. 4		2	
5. 6		3	
6. 8		4	
7. 0		5	
8. 7		2	
9. 6		0	
10. 9		1	
Total Left:		Right:	
Grand total:			
Pass/Fail:			

C. WORDS			
1. COMB		Pen	
2. Bus		CAR	
3. SPOON		Cup	
4. PEN		Fork	
5. Car		COW	
6. Ball		BUS	
7. CUP		Comb	
8. Pig		BALL	
9. FORK		Spoon	
10. Cow		PIG	
Total Left:		Right:	
Grand total:			
Pass/Fail:			

D. LETTERS			
1. H		R	
2. A		L	
3. B		F	
4. G		B	
5. C		W	
6. L		Z	
7. F		H	
8. R		G	
9. W		A	
10. Z		C	
Total Left:		Right:	
Grand total:			
Pass/Fail:			

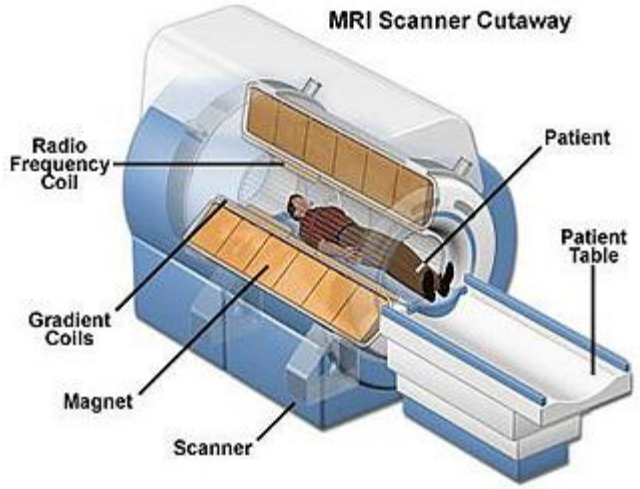
E. PICTURES			
1. Car		COW	
2. Pig		BALL	
3. CUP		Comb	
4. Ball		BUS	
5. FORK		Spoon	
6. COMB		Pen	
7. Cow		PIG	
8. Bus		CAR	
9. PEN		Fork	
10. SPOON		Cup	
Total Left:		Right:	
Grand total:			
Pass/Fail:			

F. COLOURS			
1. BLUE		White	
2. Orange		BLACK	
3. Pink		GREEN	
4. GREY		Red	
5. Green		ORANGE	
6. Yellow		PINK	
7. PURPLE		Grey	
8. Black		YELLOW	
9. RED		Blue	
10. WHITE		Purple	
Total Left:		Right:	
Grand total:			
Pass/Fail:			

Method

- Cognitive profile in comparison with neuroimaging data

  - PET scan
    - Injection of fluorodeoxyglucose
    - SPM12
    - FWE-corrected $p < 0.05$
  - Structural MRI – Voxel-based morphometry
    - SPM8
    - FWE-corrected $p < 0.05$



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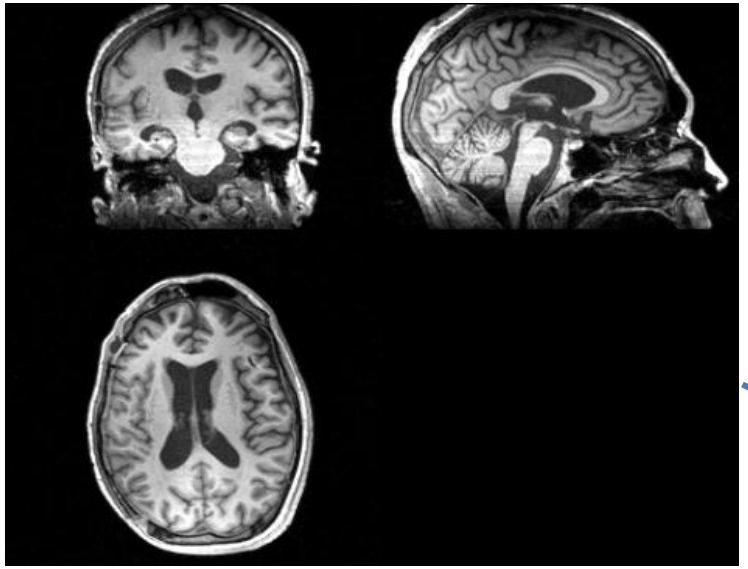
3. Results

Case 1



CAVE	Score
Real objects	9/10
Numbers	9/10
Words	9/10
Letters	10/10
Pictures	/
Colors	/
No left/right differences	

CRS-R: EMCS (functional communication)

26 years old

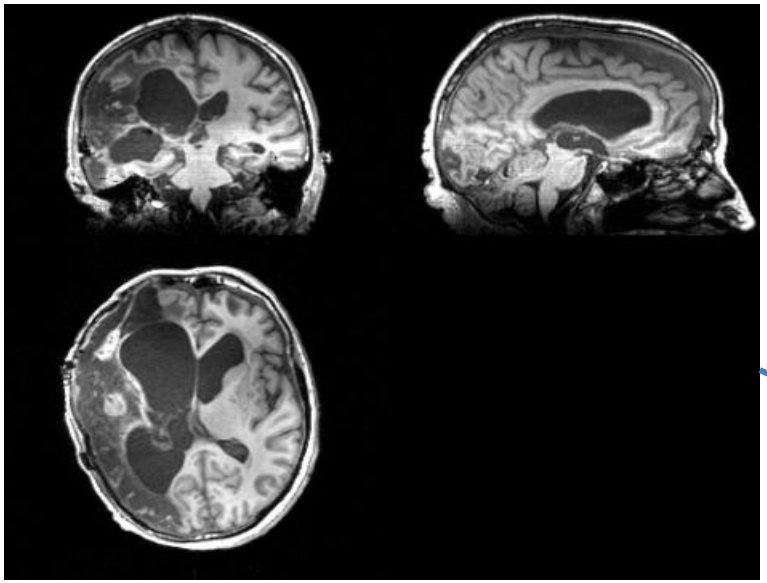
16 months post-TBI

Right-handed

Male

EEG → slow theta dysrhythmia on posterior and temporal derivations of left hemisphere

Case 2



CRS-R: EMCS (functional use of objects)

66 years old

30 months post-stroke and epilepsy

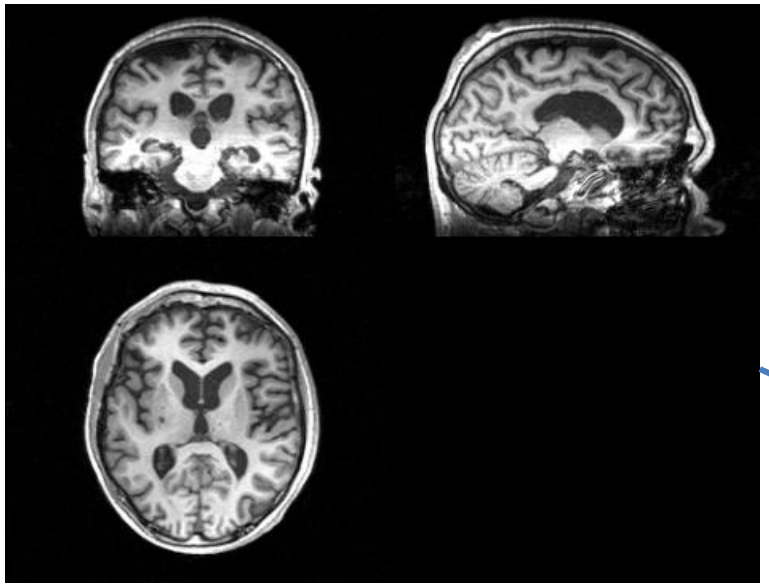
Right-handed

Male

EEG → significant left hemispheric damage with a nascent encephalopathy

CAVE	Score
Real objects	7/10
Numbers	9/10
Words	6/10
Letters	5/10
Pictures	10/10
Colors	7/10
Left/right differences	

Case 3



CAVE	Score
Real objects	10/10
Numbers	8/10
Words	1/10
Letters	7/10
Pictures	9/10
Colors	5/10
No left/right differences	

CRS-R: MCS+ (command-following)

20 years old

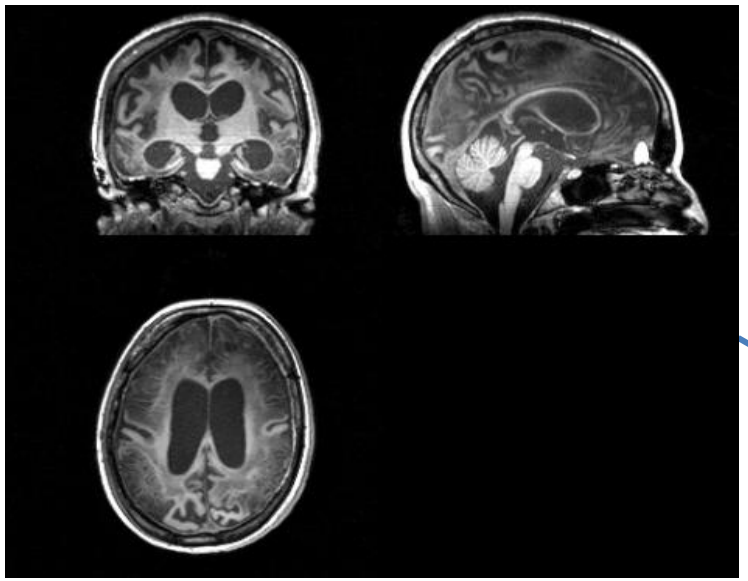
13 months post-TBI

Right-handed

Male

EEG → biased by abundant movement artifacts

Case 4



CAVE	Score
Real objects	4/10
Numbers	0/10
Words	2/10
Letters	NA
Pictures	NA
Colors	0/10
No left/right differences	

CRS-R: MCS- (visual + motor functions)

21 years old

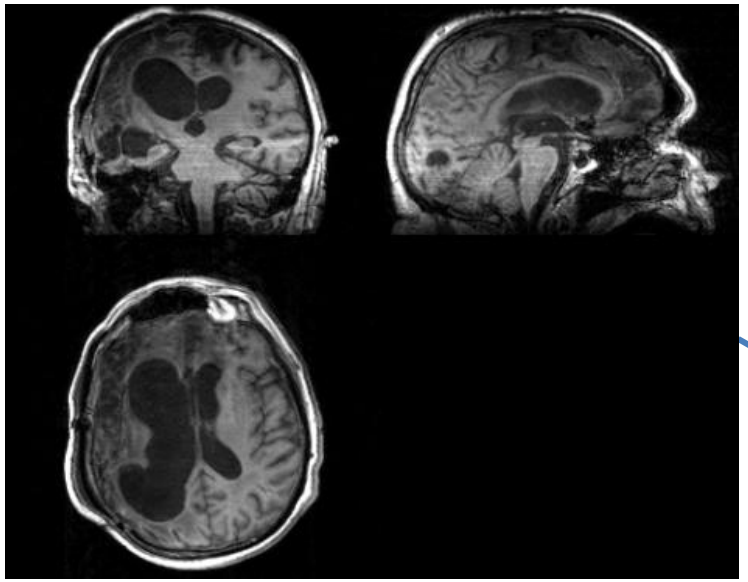
3 years post-hypoglycemia

Right-handed

Female

EEG → significant encephalopathy with no sign of lateralization

Case 5



CAVE	Score
Real objects	4/10
Numbers	3/10
Words	1/10
Letters	1/10
Pictures	3/10
Colors	2/10
Left/right differences	

CRS-R: MCS- (visual + motor functions)

64 years old

13 months post-stroke

Right-handed

Male

EEG → symmetrical slow dysrythmia with no paroxysm

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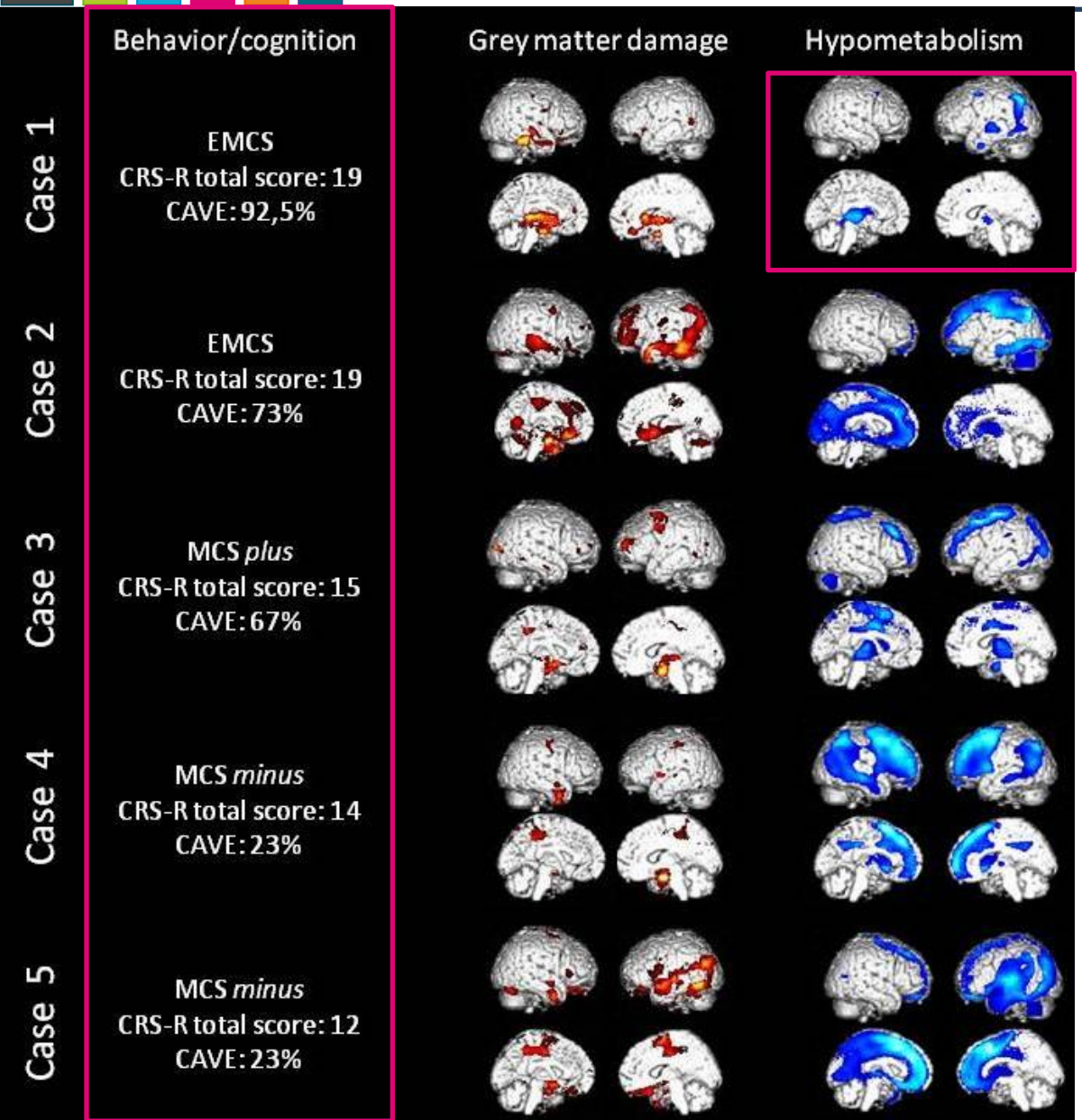
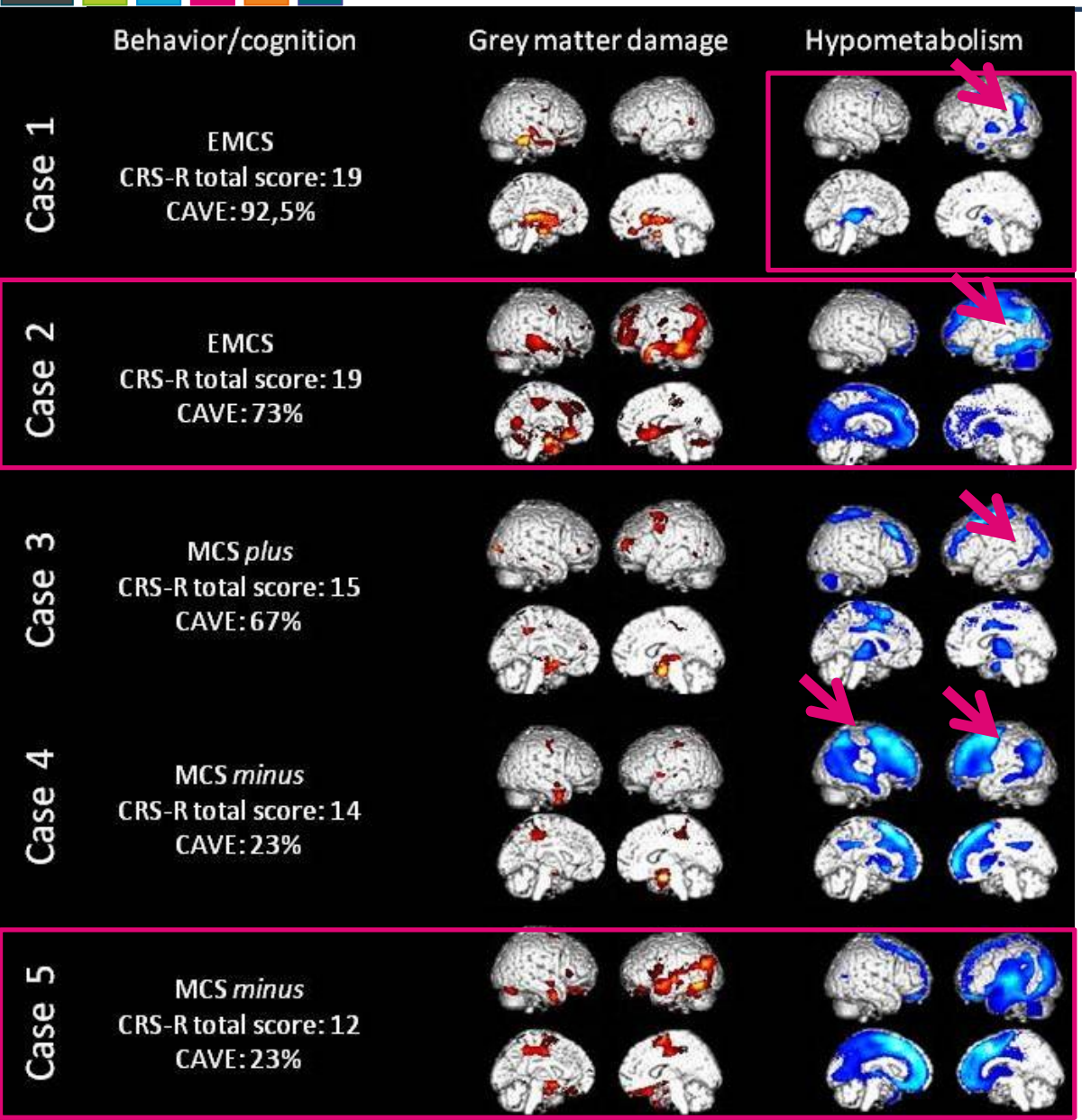
4. Discussion

Patients' general profile



- % of success on the CAVE // CRS-R total score
  → Consistent behavioral cognitive profile
- Highest scorer on bedside assessments: less extended hypometabolism
- Cognitive profile // structural/functional neuroimaging

Specific functions



- Visual fixation/pursuit
  // preserved occipital areas
- Spatial neglect
  In both patients with left GM damage +++
- Residual motor abilities
  +++ in cases 1, 2 & 4
- Residual language and executive functions
  Yes/no code in case 1 // frontal lobules ok
  +++ in cases 1, 2 & 3

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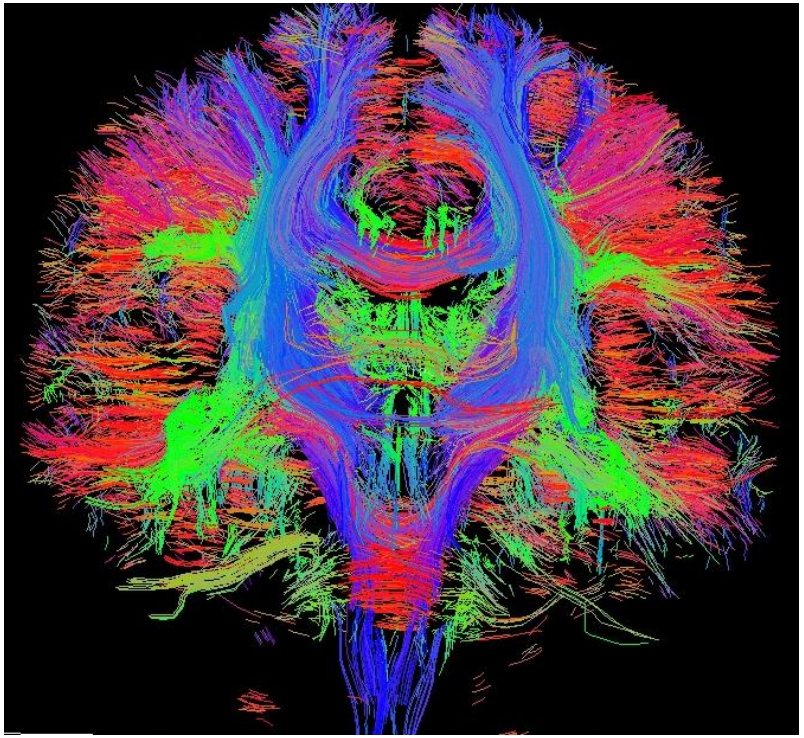
5. Take home message

Take home message

- Preliminary study!
- CRS-R & CAVE → Consistent behavioral/cognitive profile
- Brain-behavior relationships might be observed even in severely brain-injured patients
- Importance of the development of behavioral assessment tools, such as the CAVE
  - for clinical work (to refine patients' profile)
  - for scientific interest (neural correlates in patients with severe brain injury)

Thank you !



For supplementary information:

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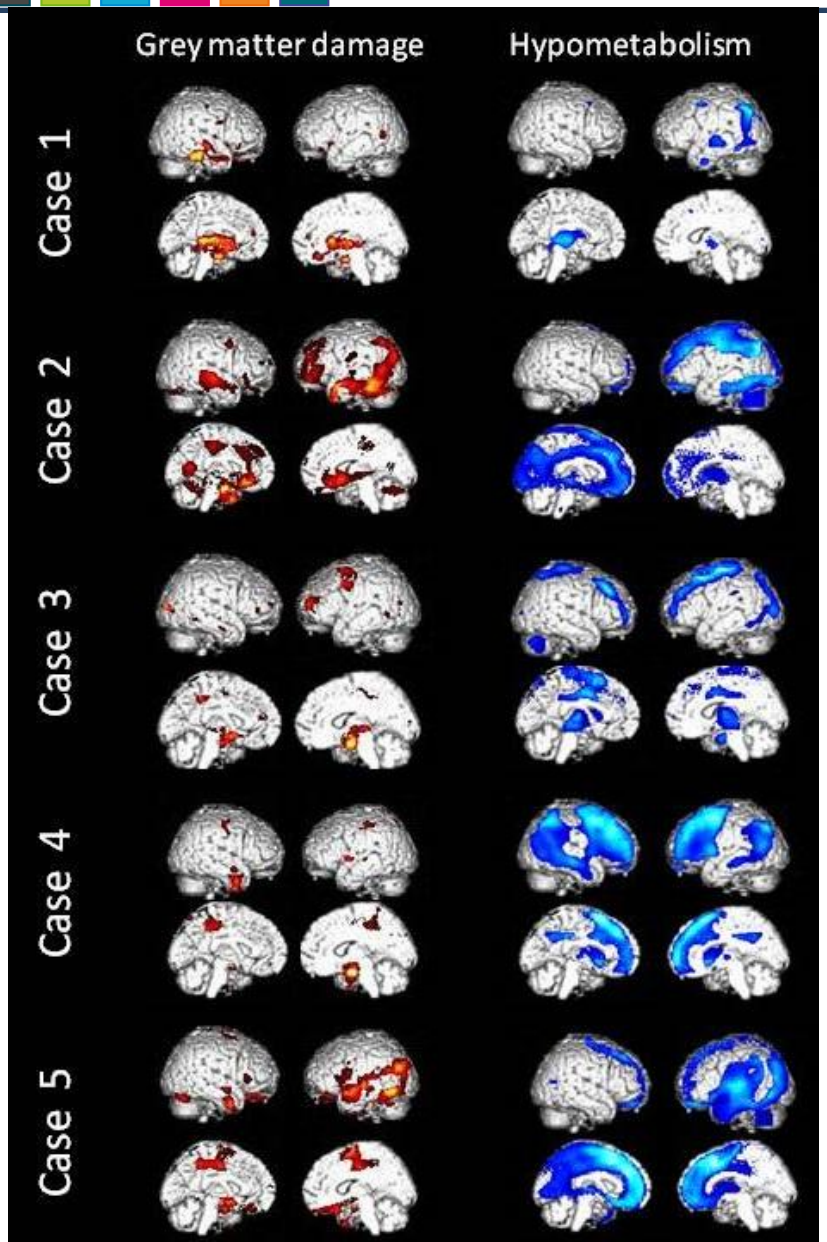

	Brain regions	*p*(FWE-corr)
GREY MATTER DAMAGE		
Case 1 < CTR	L hippocampus	0
Case 2 < CTR	L fusiform cortex	0
	L medial orbitofrontal cortex	0
	R superior temporal cortex	0,002
	L calcarine	0,035
	R cerebellum	0,038
Case 3 < CTR	R hippocampus	0,004
	L precentral cortex	0,025
	L hippocampus	0,036
Case 4 < CTR	R amygdala	0
Case 5 < CTR	L inferior temporal cortex	0
	R supplementary motor area	0,001
HYPOMETABOLISM		
Case 1 < CTR	L angular gyrus	0,016
	L thalamus	0,015
Case 2 < CTR	L inferior parietal	0
Case 3 < CTR	L precentral cortex	0
	R middle frontal cortex	0,003
	R precentral cortex	0,012
	L middle occipital cortex	0,006
	Brain stem	0,002
Case 4 < CTR	R middle frontal cortex	0
	L caudate	0,013
	L middle temporal cortex	0
	R middle cingulate cortex	0,02
Case 5 < CTR	L middle temporal cortex	0