EEG Dynamic Regimes and the Contributions of Regional Glucose Uptake in a Large Cohort of Patients With Prolonged Disorders of Consciousness

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Background

- The **mesocircuit hypothesis** proposes that recovery of consciousness for patients with a DoC is mediated by intricate interactions between the brainstem, thalamus, basal ganglia, and cortex (**Fig. 1**) [1]
- The evaluation of **EEG power spectra** can be used as a surrogate to assess the integrity of this network
- The ABCD model hereby defines **four dynamic regimes** ranging from complete cortical deafferentation to intact brain activity, as has been observed for patients in the acute stage of a DoC following brain injury [2]
- In this work, we set out to:
  1. Apply the ABCD model in **prolonged DoC** and associate this with diagnosis
  2. Validate the EEG findings with the **cerebral glucose metabolism** (FDG-PET)
  3. Provide **recommendations** for clinical translation

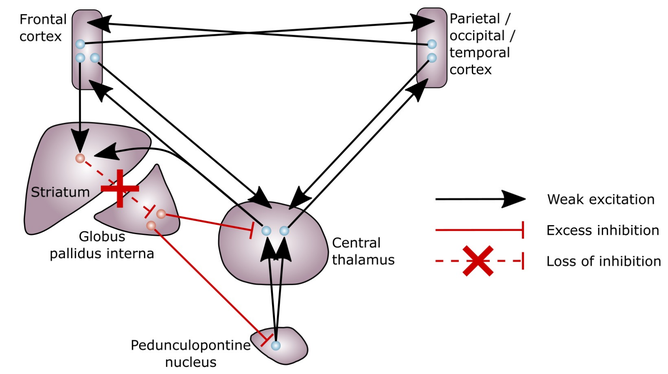


Fig. 1 Illustration depicting the main actors comprising the mesocircuit, and the disturbance following severe brain injury

Methods

- **Three raters** performed **ABCD classification** of EEG power spectra **twice**
- **Intra, inter, and over-rater** (w.r.t. a consensus) **agreement** was calculated (Cohen's kappa) and ABCD **categories per diagnostic group** evaluated
- **Six external raters** performed the classification using **practical guidelines**
- Category-wise **relative band power** was evaluated quantitatively
- Relative power from **source-reconstructed EEG** was regionally **associated with cerebral SUV** (standardized uptake value)
- AFNI's **region-based analysis** was used to evaluate the **contribution of regional SUV to the ABCD categories** [3]

Results

CLASSIFICATION & GUIDELINES

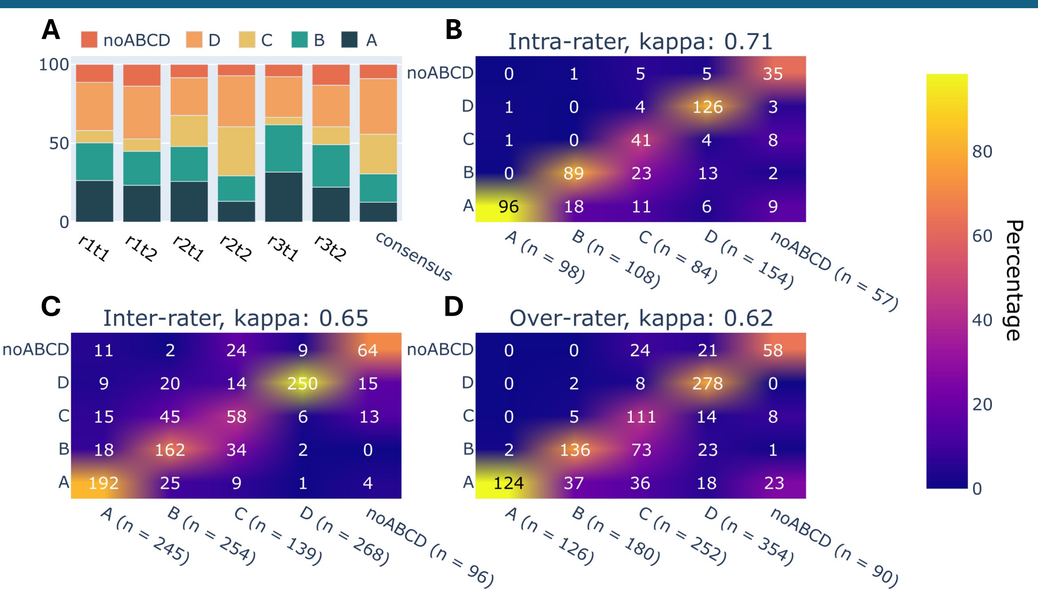
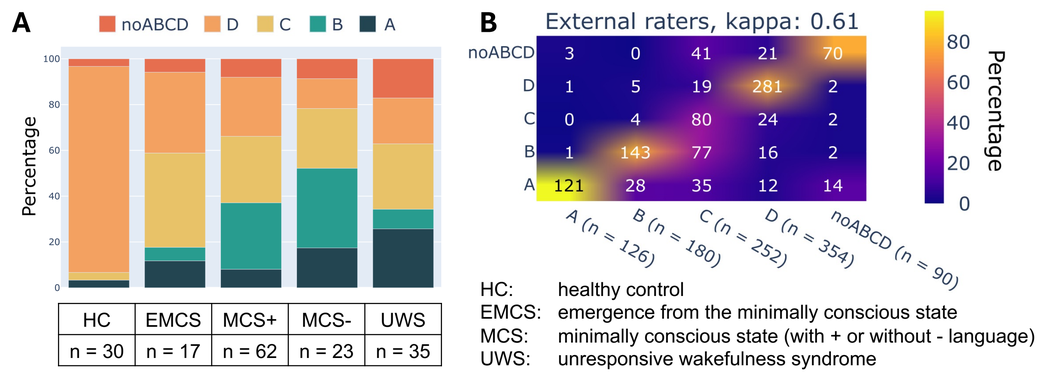


Fig. 2 A) Distribution of scored categories by the main raters r_i and sessions t_j, **B/C/D**) counts and column-wise percentage of scoring within raters, between raters, and relative to a consensus scoring, respectively



HC	EMCS	MCS+	MCS-	UWS
n = 30	n = 17	n = 62	n = 23	n = 35

HC: healthy control
EMCS: emergence from the minimally conscious state
MCS: minimally conscious state (with + or without - language)
UWS: unresponsive wakefulness syndrome

Fig. 3 A) Distribution of ABCD categories over groups – with which they were significantly associated ($\chi^2(16) = 69.010$, $p < 0.001$), **B**) average external raters' classification result compared to the consensus

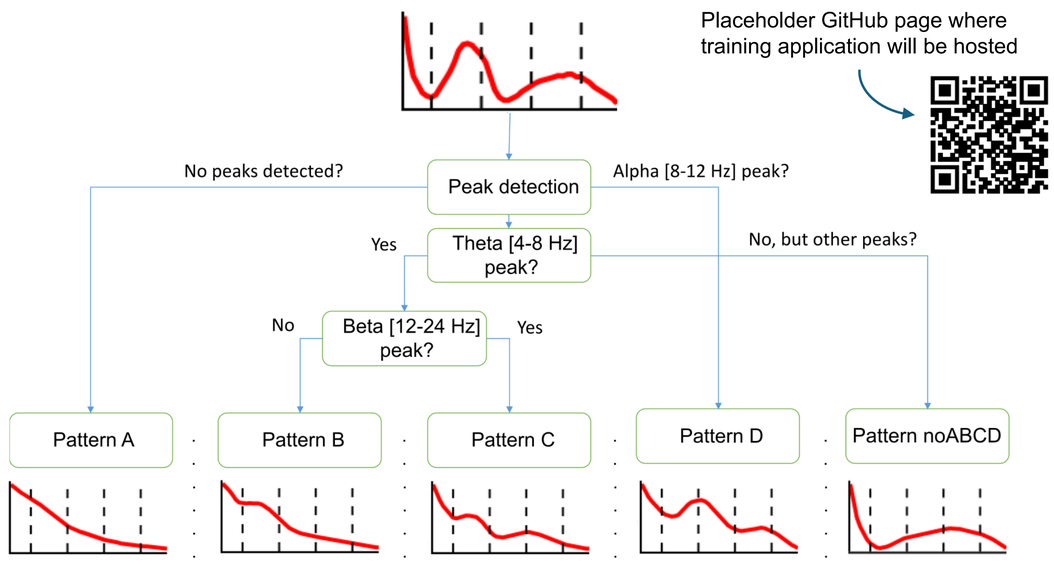


Fig. 4 Proposed flowchart diagram for ABCD classification in practice

ELECTROPHYSIOLOGICAL & METABOLIC

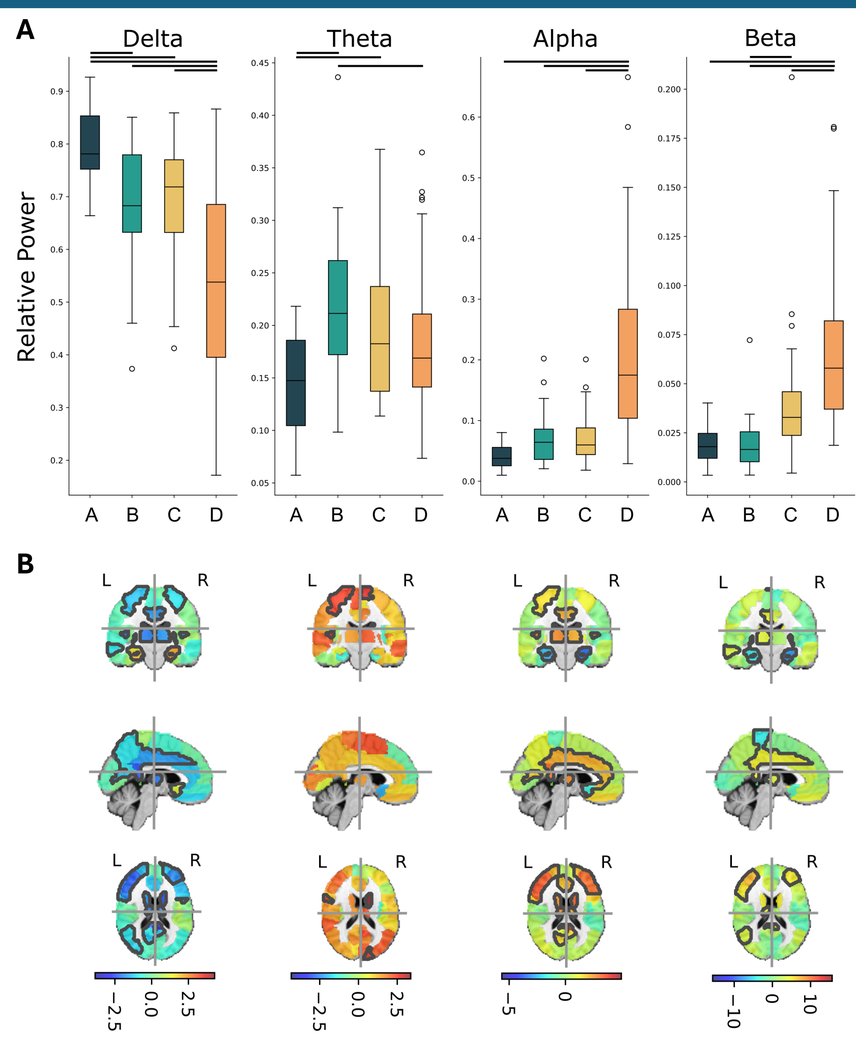
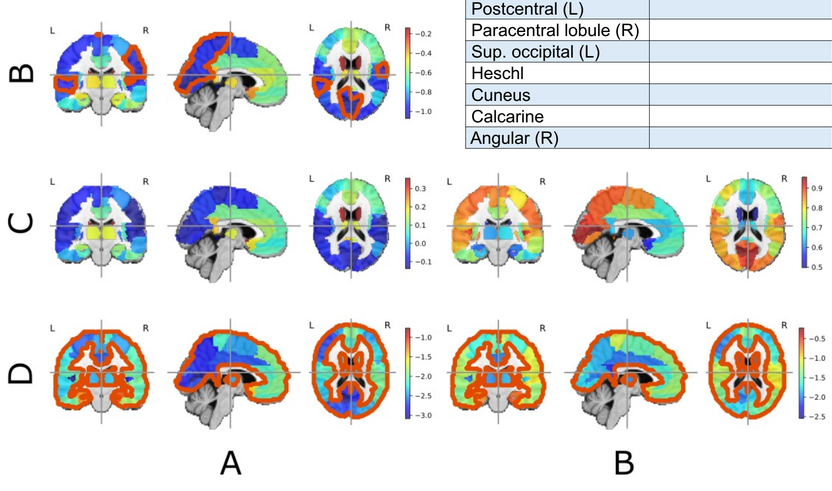


Fig. 5 A) Distributions of relative power over frequency bands for ABCD categories – reflecting the definitions of A (dominant delta), B (theta), C (theta & beta), and D (alpha & beta), **B**) results of linear mixed model, representing the associations between source-level relative power and regional SUV (significant regions highlighted)



A | B	A | D	B | D	C | D
Sup. temporal (R)	*All regions, except:*	*All regions, except:*	*All regions*
Precuneus (R)	Amygdala	Sup. temporal pole (L)	
Postcentral (L)		Parahippocampus	
Paracentral lobule (R)		Hippocampus (L)	
Sup. occipital (L)		Amygdala	
Heschl			
Cuneus			
Calcarine			
Angular (R)			

Fig. 6 Region-based analysis results, with significantly differing regions highlighted and specified in the table

Discussion

- There was substantial intra, inter, and over-rater agreement when assigning ABCD categories, indicating feasibility of their identification in prolonged DoC
- To reduce subjectivity, practical guidelines were proposed to facilitate clinical and academic translation, which have been adapted into an online application
- ABCD categories' properties are confirmed using quantitative spectral analysis
- There is a direct relationship between regional glucose metabolism and brain-level EEG band power, most prominent in midline and frontoparietal regions
- From the PET region-based analysis follows that:
  - Posterior regions contribute to the difference between A and B
  - No specific metabolic differences were found between B and C
  - D comparatively shows higher glucose metabolism in virtually all regions

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References:
[1] Schiff, *Trends Neurosci.* 2010
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