# **Behavioral signs associated with recovery of consciousness after severe brain injury**

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# **Abstract**

**Objectives:** To determine which features of minimally conscious state (MCS) emerge first in patients transitioning from the vegetative state (VS) to MCS following severe traumatic and non-traumatic brain injury.

**Design:** Retrospective observational study.

**Setting:** Inpatient Setting with a Specialized Disorders of Consciousness (DoC) program.

**Participants:** 65 patients who met criteria for MCS for the first time during their inpatient stay (44 male; mean age+/-SD = 43.6+/-19.8; TBI = 31; median time since injury [IQR]: 42 days [32 – 54]).

**Interventions:** N/A

**Main Outcome Measures:** MCS behaviors detected on the Coma Recovery Scale-Revised (CRS-R).

**Results:** At transition from VS to MCS, visual pursuit was the most frequently observed MCS behavior (39% of patients), followed by automatic response (32%), reproducible movement to command (29%), intentional communication (19%) and visual fixation (12%). Each one of the remaining MCS behaviors (i.e., localization to pain, object manipulation, intelligible verbalization, object recognition, object localization and consistent movement to command) was present in less than 5% of the patients. In patients who showed only one behavioral sign of consciousness at emergence from VS (71% of sample), visual pursuit was most prevalent, occurring in 41% of cases. In patients who demonstrated two MCS behaviors concurrently at time of emergence (9% of sample), transitional features involved visual and motor functions in 44% of cases. Only 2% of patients demonstrated MCS behaviors across all 5 CRS-R subscales that include MCS features.

**Conclusions:** Patients with DoC transitioning from VS to MCS typically recover cognitively-mediated visual and motor behaviors. Most patients initially demonstrate only one behavioral sign of consciousness, highlighting the importance of performing comprehensive serial assessments in this population.

Key words: brain injury, vegetative state, minimally conscious state

Learning objectives:

* Identify the most frequent behavioral signs of consciousness to emerge following severe brain injury
* Describe the behavioral profile of patients transitioning from vegetative state to minimally conscious state
* Identify the challenges of diagnosing patients with disorders of consciousness using behavioral assessments

Géraldine Martens, MSc

Géraldine Martens is a physical therapist and PhD student at the GIGA Consciousness - Coma Science Group at University of Liège, Belgium, under the supervision of Prof. Steven Laureys. She is currently completing a one year graduate research fellowship in the Neurorehabilitation Lab at Spaulding Rehabilitation Hospital in Charlestown, MA, under the direction of Dr. Joseph Giacino. Geraldine's main clinical and research interests are in the application of transcranial direct current stimulation (tDCS) to promote recovery of consciousness after severe brain injury and in prevention and management of spasticity in patients with chronic disorders of consciousness (DoC). She is also interested in improving bedside diagnostic accuracy of DoC using standardized assessments such as the Coma Recovery Scale-Revised.

Yelena Bodien, PhD

At the core of Dr. Bodien’s scientific pursuits is using advanced neuroimaging techniques to progress understanding of the neurobiology of severe brain injury and improve the precision of patient assessment and outcome. Three areas of research represent the majority of Dr. Bodien’s investigative focus. First, in collaboration with BWH and the international Coma and Consciousness Consortium, she is developing an fMRI paradigm for detection of conscious awareness in patients with severe traumatic brain injury. Second, Dr. Bodien participates in an ongoing effort to improve standardized approaches to detecting conscious awareness at the bedside. Finally, she is a core member of the Transforming Research and Clinical Knowledge in TBI initiative which is collecting clinical data, CT/MR Imaging, blood biospecimens, and detailed outcomes on 3000 subjects across the US which will be used to phenotype traumatic brain injury as well as identify new diagnostic and prognostic markers and refine outcome assessments in this population. Dr. Bodien is an active member of the American Congress for Rehabilitation Medicine and participates in the Brain Injury Interdisciplinary Special Interest Group that publishes evidence-based literature reviews. In that capacity, she is currently working to develop a case definition for the Post Traumatic Confusional State.

Kristen Sheau, MSc

Kristen Sheau is an occupational therapy doctoral student at the Massachusetts General Hospital Institute of Health Professions (MGHIHP) in Boston and a student intern in the Neurorehabilitation Laboratory at Spaulding Rehabilitation Hospital, under the direction of Dr. Joseph Giacino. She is interested in measurement of functional motor recovery in disorders of consciousness, and has prior research experience in neuroimaging in clinical populations including chronic pain and pediatric neurodevelopmental disorders.

Andrea Christoforou, PhD

Dr. Andrea Christoforou completed her doctoral and initial post-doctoral work in the field of psychiatric genetics, before returning to school in 2012 to train as a physical therapist. In 2016, she joined the Neurorehabilitation Lab at Spaulding Rehabilitation Hospital as a post-doctoral fellow, where she has been primarily involved in the development of an evidence-based assessment platform for the validation of TBI clinical outcome assessment measures and has become increasingly more involved in the design and/or analyses of studies that aim to elucidate natural history, treatment potential and long-term outcome of individuals with moderate to severe TBI.

Joseph Giacino, PhD

Joseph T. Giacino, PhD is the Director of Rehabilitation Neuropsychology and Research Associate in the Department of Physical Medicine and Rehabilitation at Spaulding Rehabilitation Hospital in Boston, Massachusetts, Consulting Neuropsychologist in the Department of Psychiatry at Massachusetts General Hospital, Associate Professor in the Department of Physical Medicine and Rehabilitation at Harvard Medical School and Adjunct Professor at the MGH Institute of Health Professions. He directs the Spaulding Rehabilitation Hospital Neurorehabilitation Laboratory which focuses on the development and application of novel assessment and treatment methods for individuals with severe acquired brain injury (ABI) and disorders of consciousness (DoC). He served as co-chair of the Aspen Workgroup which established the diagnostic criteria for the minimally conscious state (MCS) and currently chairs the DoC Guideline Development Panel, co-sponsored by the American Academy of Neurology, American Congress of Rehabilitation Medicine and National Institute on Disability, Independent Living and Rehabilitation Research (NIDILRR). He is the Project Director and PI for the Spaulding-Harvard TBI Model System (NIDILRR), serves as Co-PI on the “Transforming Research and Clinical Knowledge in TBI (TRACK-TBI)” (NIH-NINDS) and “TBI Endpoint Development (TED)” (DoD) projects, both of which are validating clinical, imaging, genomic and outcome markers to enable more precise TBI diagnosis, prognosis and treatment. He is also Co-PI on an NINDS-funded Advanced Neural Prosthetics Research and Development grant investigating “Central Thalamic Stimulation for Traumatic Brain Injury” and PI on a TED seed grant that is developing an Evidence-Based Clinical Outcome Assessment Platform for evaluation of TBI clinical outcome assessment measures intended for use in FDA approved drug and device trials. In his clinical role, Dr. Giacino directs the Spaulding Rehabilitation Network DoC Program and maintains a broad array of national and international collaborations aimed at improving care for patients with severe TBI.