

## Measurements of consciousness in the vegetative state



In *The Lancet*, Damian Cruse and colleagues' study<sup>1</sup> examines 16 patients in the vegetative state. This disorder is defined as wakefulness without conscious awareness of self and environment. The investigators showed that three (19%) of the 16 patients could generate EEG responses to two commands involving motor imagery, although the patients were otherwise behaviourally unresponsive. But how can this discovery be understood?

Researchers typically accept a distinction between the contents and levels of consciousness.<sup>2</sup> Contents of consciousness are defined as subjective experience—eg, the taste of coffee, feeling of pain, or experience of the colour red. In the study of levels of consciousness,<sup>2</sup> three distinct stages of degraded consciousness have been described: coma, the vegetative state, and the minimally conscious state. Differentiation between the stages is based on behavioural criteria. Patients in the vegetative state differ from those in a coma because they can be aroused, yet both groups are considered fully unconscious. Patients in the minimally conscious state are believed to have fluctuating consciousness and are distinguished from the vegetative state when an outside observer (a doctor in most cases) thinks the patient has a minimum understanding of self or the environment (eg, a voluntary attempt to communicate). Other patients with severe brain injury, who are not in the minimally conscious state, are typically believed to be more conscious<sup>3</sup> than minimally conscious patients.

Immediate problems occur with attempts to operationalise these definitions, not least with the aim to develop a bedside test for consciousness. Levels of consciousness, in the standard scale, are defined as perceptible signs of being in contact with the outside world. Whereas this definition might make intuitive sense, it is not identical to subjective experience. In cognitive science, nearly all mental events exist with and without consciousness. Complex types of behaviour, response inhibition, task switching, instruction following, conflict monitoring, and error detection have all been described as fully functional in the absence of reportable conscious experience.<sup>4</sup> Similarly, complex aspects of perception, such as semantic interpretation, can occur unconsciously.<sup>5</sup>

No patient has been discovered who could follow instructions, yet was completely unconscious. However,

with the scarcity of external validation methods in the study of consciousness, to imagine how such a patient could be identified is difficult. Yet findings from some studies<sup>6</sup> indicate that so-called split-brain patients react to commands without (reported) awareness of the command. From a different perspective, many published works<sup>7</sup> discuss the possible dissociation between the neural substrate of vision for action and vision for perception (and perceptual consciousness). Therefore, command following, which was used as an objective indicator for consciousness in Cruse and colleagues' study,<sup>1</sup> might not be an absolute measure for identification of whether a person is conscious. Because three (25%) of the 12 healthy controls in this study could not produce significant EEG records, command following most likely measures something different than the presence and absence of consciousness.

Nevertheless, the new discovery by Cruse and colleagues is surprising and challenging. The study continues a line of research with other revolutionary findings—eg, that of Owen and colleagues,<sup>8</sup> who instructed a patient in the vegetative state to “imagine playing tennis” or “imagine visiting the rooms in your house”. The resulting brain activation was no different from that of control participants. In a follow-up study,<sup>9</sup> this technique was applied to communicate successfully with five of 54 patients in the vegetative state, by asking them to think about tennis for “yes”, and being in their house for “no”. With Cruse and colleagues' study,<sup>1</sup> these

Published Online  
November 10, 2011  
DOI:10.1016/S0140-  
6736(11)61591-2

See Online/Articles  
DOI:10.1016/S0140-  
6736(11)61224-5



findings present good evidence that at least some patients in the vegetative state are conscious. However, the methods in all these experiments are indirect and investigate a factor other than consciousness alone.

So far, most researchers have interpreted these published results as suggesting that many patients in the vegetative state are wrongly diagnosed; however, these studies have an even stronger consequence. The real underlying issue is that the levels of consciousness have little to do with consciousness—ie, subjective experience. A more plausible interpretation is that vegetative and minimally conscious states distinguish between different levels of cognitive and communicative abilities, which is a different matter than subjective experience per se. A new classification system is necessary if the goal is to understand the cognitive functioning of patients in the vegetative or minimally conscious states. Such a system should begin with a much more explicit attempt to use objective methods that have been correlated with reports of subjective experience in healthy individuals.<sup>10</sup>

\*Morten Overgaard, Rikke Overgaard  
Cognitive Neuroscience Research Unit (CNRU), Department of  
Communication and Psychology, Aalborg University,  
9220 Aalborg Oest, Denmark (MO); and Hammel  
Neurorehabilitation and Research Center (MO), and CNRU Centre  
of Functionally Integrative Neuroscience (RO), MindLab, Aarhus  
University, Aarhus, Denmark  
mortover@rm.dk

MO was funded by a Starting Grant from the European Research Council. We declare that we have no conflicts of interest.

- 1 Cruse D, Chennu S, Chatelle C, et al. Bedside detection of awareness in the vegetative state: an observational cohort study. *Lancet* 2011; published online Nov 10. DOI:10.1016/S0140-6736(11)61224-5.
- 2 Laureys S. The neural correlate of (un)awareness: lessons from the vegetative state. *Trends Cogn Sci* 2005; **9**: 556–59.
- 3 Overgaard M. How can we know if patients in coma, vegetative state or minimal conscious state are conscious? *Prog Brain Res* 2009; **177**: 11–19.
- 4 van Gaal S, Lamme VA. Unconscious high-level processing: Implications for neurobiological theories of consciousness. *Neuroscientist* 2011; published online May 31. DOI:10.1177/1073858411404079.
- 5 Marcel AJ. Conscious and unconscious perception: an approach to the relations between phenomenal experience and perceptual process. *Cogn Psychol* 1983; **15**: 238–300.
- 6 Cooney JW, Gazzaniga MS. Neurological disorders and the structure of human consciousness. *Trends Cogn Sci* 2003; **7**: 161–65.
- 7 Milner AD, Goodale MA. Two visual systems re-viewed. *Neuropsychologia* 2008; **46**: 774–75.
- 8 Owen AM, Coleman MR, Boly M, Davis MH, Laureys S, Pickard J. Detecting awareness in the vegetative state. *Science* 2006; **313**: 1402.
- 9 Monti MM, Vanhaudenhuyse A, Coleman MR, et al. Willful modulation of brain activity in disorders of consciousness. *N Engl J Med* 2010; **362**: 579–89.
- 10 Overgaard M, Overgaard R. Neural correlates of contents and levels of consciousness. *Front Psychol* 2010; **1**: 1–3.