Chapter 10
Brain-Computer Interfaces for Assessment and Communication in Disorders of Consciousness

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ABSTRACT

Many patients with Disorders of Consciousness (DOC) are misdiagnosed for a variety of reasons. These patients typically cannot communicate. Because such patients are not provided with the needed tools, one of their basic human needs remains unsatisfied, leaving them truly locked in to their bodies. This chapter first reviews current methods and problems of diagnoses and assistive technology for communication, supporting the view that advances in both respects are needed for patients with DOC. The authors also discuss possible solutions to these problems and introduce emerging developments based on EEG (Electroencephalography), fMRI (Functional Magnetic Resonance Imaging), and fNIRS (Functional Near-Infrared Spectroscopy) that have been validated with patients and healthy volunteers.

INTRODUCTION

The clinical care and rehabilitation approaches involving patients diagnosed with disorders of consciousness (DOC) are of great medical and social importance. The progressive increase in the number of surviving patients and their increasing life expectancies, in all industrialized countries, reflects the advancement of knowledge and techniques in the field of reanimation, as well as improved quality of care. An accurate early diagnosis is indispensable to develop early and effective standards of care, appropriate to an individual patient's condition. The clinical diagnosis of these patients is a major challenge because of the very fine line between the Vegetative State/ Unresponsive Wakefulness Syndrome (VS/UWS; Laureys et al., 2010), characterized by preserved arousal in the absence of behavioral signs of awareness, the Minimally Conscious State (MCS), with non-reflexive albeit inconstant purposeful behaviors, and the Locked-In Syndrome (LIS), in which consciousness is fully preserved (Giacino et al., 2002). Recent work identified two groups within this patient population - those who show higher-order signs of consciousness (*e.g.*, command following, intelligible verbalization, and non functional communication; *i.e.* MCS plus) versus those who show only low-level signs of consciousness (*e.g.*, visual pursuit of a salient stimulus, noxious stimulation localization, appropriate emotional response; *i.e.* MCS minus) (Bruno et al., 2011; Bodart et al., 2013).

Despite the efforts already made to improve the instrumental diagnosis, differential diagnosis between different patients with an altered state of consciousness is eminently clinical and based on a list of items that the patient is unable to perform. The LIS is a term introduced by Plum and Posner to describe a neurological condition