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CHAPTER 28

# Behavioral evaluation of consciousness in severe brain damage

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**Abstract:** This paper reviews the current state of bedside behavioral assessment in brain-damaged patients with impaired consciousness (coma, vegetative state, minimally conscious state). As misdiagnosis in this field is unfortunately very frequent, we first discuss a number of fundamental principles of clinical evaluation that should guide the assessment of consciousness in brain-damaged patients in order to avoid confusion between vegetative state and minimally conscious state. The role of standardized behavioral assessment tools is particularly stressed. The second part of this paper reviews existing behavioral assessment techniques of consciousness, showing that there are actually a large number of these scales. After a discussion of the most widely used scale, the Glasgow Coma Scale, we present several new promising tools that show higher sensitivity and reliability for detecting subtle signs of recovery of consciousness in the post-acute setting.

## Introduction

The evaluation of consciousness in severely brain-damaged patients is of major importance for their daily management. Consciousness is a multifaceted concept that, in a simplified manner, can be divided into two major components: the *level* of consciousness (i.e., arousal, wakefulness or vigilance) and the *content* of consciousness (i.e., awareness of the environment and of the self) (Plum and Posner, 1983). Arousal is supported by numerous brainstem neuronal populations (previously called reticular activating system) that directly project to both thalamic and cortical neurons (see Fig. 1). Therefore, depression of either brainstem or global hemispherical function may cause reduced wakefulness. Awareness is thought to be dependent upon the functional integrity of the cerebral cortex and its reciprocal subcortical connections; each of its many aspects resides to some extent in anatomically defined regions of the brain.

Unfortunately, for the time being, consciousness cannot be measured objectively by any machine. Its estimation requires the interpretation of several clinical signs. Many scoring systems have been developed for the quantification and standardization of the assessment of consciousness. The present paper will discuss the strengths and pitfalls of a behavioral assessment of consciousness in patients, with a special focus on patients in a vegetative state, and discuss new promising assessment tools. Neurophysiological assessment of consciousness as well as the prognostic value of assessment in patients with impaired consciousness will not be

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neuro-physiological diagnosis. While there have been exciting developments in the use of functional MRI (Magnetic Resonance Imaging) scanning (see Schiff, this volume; Owen, this volume), brain mapping and other neuro-physiological approaches (see Kotchoubey, this volume; Guerit, this volume) these are primarily aids to diagnosis rather than a method of diagnosis. Consider, for instance, the patient whose neuro-physiological investigations suggest that there is some integrated "higher-level" cerebral function in response to stimulation — but where there is no behavioral evidence that the person is aware of his environment — who shows no evidence of communication or understanding of what others are communicating with him. Where does that leave the patient, the family and the caring team? While it might incite to reexamine the clinical responses and strive harder to demonstrate any awareness, if the patient continues with no meaningful responses and remains clinically vegetative, then we would argue that the patient is in the vegetative state.

This, however, does lead us on to questioning how sensitive our clinical–behavioral assessments are. Giacino and Zasler (1995) have pointed out the limitations of clinical assessment in the identification of "internal awareness" in a patient who otherwise lacks the motor function to demonstrate his awareness. The concept that we are only able to *infer* the presence or absence of conscious experience is a long-standing philosophical issue, which has been pointed out by Bernat (1992) and The Multi-Society Task Force (1994) in the specific context of the vegetative state. The International Working Party on the Vegetative State (Andrews, 1996) discussed this point in detail and criticized the use of the term "meaningful response" on the grounds that it requires a considerable amount of subjective interpretation on the part of the observer and that what was meaningful for the patient may not be considered meaningful by those treating the patient. Similarly the term "purposeful response" was criticized because of the subjective interpretation and that a withdrawal reflex could be considered as purposeful in that it removes the limb, for instance, from danger.

This is where there must be some concern. For instance there are several studies that have described the misdiagnosis of the vegetative state. In a group of long-term patients in a nursing home in the USA, Tresch et al. (1991) found that 18% of those diagnosed as being in the persistent vegetative state were aware of themselves or their environment. Childs et al. (1993) report that 37% of patients admitted more than 1 month post-injury with a diagnosis of coma or persistent vegetative state had some level of awareness. In another study (Andrews et al., 1996), 43% of patients admitted to a profound brain injury unit at least 6 months following their brain damage (i.e. could be expected to be stable) were found to have been misdiagnosed. While these figures cause concern they at least emphasize that bedside diagnosis was possible — otherwise they would not have been identified as having been misdiagnosed.

So why are patients misdiagnosed? One striking finding was that 65% of the "misdiagnosed" patients were either blind or very severely visually impaired in the form of marked visual field defects and/or visual perceptual disorders (Andrews et al., 1996). This has obvious implications for assessment since one of the prime features for assessing whether a patient is non-vegetative is eye tracking. If the patient has visual impairment, then he will not follow objects and therefore eye tracking will be absent even in a mentally alert individual.

Since all patients followed verbal commands, it is assumed that none were deaf or had severe hearing impairment. This, however, is a possibility and should be considered. This also emphasizes the importance of assessing a wide range of stimuli (touch, taste and smell as well as visual or auditory), a range of frequent observations with standardized assessment tools and optimal patient management (e.g., with the patient in seating position) to ensure that disturbance of one modality is not the cause of missing evidence of awareness.

### *Making the diagnosis of vegetative state*

Previous studies have shown that misdiagnosed "vegetative" patients were at the "severe" level of the Glasgow Outcome Scale (Jennett and Teasdale, 1977), being totally physically dependent for all care needs (Andrews et al., 1996). The only tightens as there is an attempt to pull the hand or fingers away. This is supportive of the diagnosis of a grasp reflex rather than supportive of a meaningful response.

What can be even more confusing are the fragments of coordinated movement, such as scratching or even moving hands toward a noxious stimulus. These must always be taken seriously as indicating awareness but do occur in the vegetative patient usually affecting the same repetitive movement on each occasion. They are probably long-learned automatic response activities. However, scratching oneself on different locations depending on the irritant's source would be indicative of a minimally conscious state.

Chewing movements or grinding of teeth (to which can be added constant movement of the tongue) again cause concern to relatives and carers feeling that the patient is indicating that he is thirsty or hungry. Grunting and groaning provoked by noxious stimuli can also often be interpreted as indicating an attempt to communicate. This can cause disagreement between family and clinicians when some relatives claim to be able to "understand" the words spoken when others only hear sounds. These are, however, commonly found features in the vegetative state. The skills is to decide whether the responses are contingent on the quality of the external stimulus.

*Factors influencing the diagnosis*

The International Working Party (Andrews, 1996) pointed out that the assessments in general use are based on a series of behavioral patterns. The clinician is, therefore, dependent on overt responses that depend on a number of factors including:

a. The physical ability of the patient to respond — this has been discussed above.
b. The desire or willingness (if the patient is aware) of the patient to respond. It is not unusual for members of the family to obtain responses that the professional members of the team are not able to. This is probably not surprising since the members of the family are more likely to be "sensitive" to the responses seen. On the other hand, the family may be desperate for a response and easily misinterpret the reflex responses. Patients may also be more willing to respond to family or to some members of the staff rather than to others. Let us face facts — some staff are better at relating than others.
c. The ability to observe accurately. This is particularly relevant since profound brain damage is a rare condition and few professionals have seen sufficient patients to have gained that level of experience required to produce "expertise".
d. The time available for observation and assessment. Time is one of the major factors in assessing the profoundly brain-damaged patients. They do not conveniently have their best levels of awareness at the time set aside for the formal assessment. This requires flexibility of the assessor to take advantage of the windows of opportunity and to take advantage of the observations of other members of the team and members of the family.
e. The lack of available and reliable assessment tools. It is not so much that there is a shortage of tools — see discussion below — but that they are not used in more general acute, or even neurological or rehabilitation, units.
f. The patient is not always seen by a skilled team to address all of these issues.
g. The family and carers and those who know the patient best are not always involved as much as they should be.
h. Patients are assessed by some assessors who are unfamiliar with the patient — leading to meaningful responses being missed.

There are several principles to the accurate assessment of the person thought to be in the vegetative state:

1. That the patient should be healthy. Even simple conditions such as constipation, chronic urinary tract infection (usually associated with long-term catheterization) or bronchial infections can prevent optimal responses from being obtained.
2. The patients should be in a good nutritional state. The earlier use of gastrostomy feeding has altered this pattern but still some patients

Rehabilitation Technique (SMART; Gill-Thwaites, 1997, 1999).

### *Glasgow coma scale*

Teasdale and Jennett (1974) developed the GCS as an aid in the clinical assessment of post-traumatic unconsciousness. It was devised as a formal scheme to overcome the ambiguities that arose when information about comatose patients was presented and groups of patients compared. The GCS has three components: eye (E), verbal (V) and motor (M) response to external stimuli (see Fig. 2). The scale consisted of 14 points, but was later adapted to 15, with the division of the motor category "flexion to pain" into two further categories. The best or highest responses are recorded. So far, more than 2390 publications have appeared to its use (MEDLINE search performed in February 2005, limited to title and abstract word). It is a component of the Acute Physiology and Chronic Health Evaluation (APACHE) II score, the (Revised) Trauma Score, the Trauma and Injury Severity Score (TRISS) and the Circulation, Respiration, Abdomen, Motor, Speech (CRAMS) Scale, demonstrating the widespread adoption of the scale.

The observation of spontaneous eye opening "indicates that the arousal mechanisms of the brainstem are active" (Teasdale and Jennett, 1974). As previously stated, recovered arousal does not imply the recovery of awareness. Patients in a vegetative state have awakened from their coma but remain unaware of their environment and self. Most comatose patients who survive will eventually open their eyes, regardless of the severity of their cerebral damage (Jennett, 1972). Indeed, less than 4% of head-damaged patients never open their eyes before they die (Bricolo et al., 1980). The eye opening in response to speech tests the reaction "to any verbal approach, whether spoken or shouted, not necessarily the command to open the eyes" (Teasdale and Jennett, 1974). Again, this response is observed in the vegetative state where "awakening" can be induced by non-specific auditory stimulation. In these patients, it is recommended to differentiate between a reproducible response to command and to nonsense speech. Eye opening in response to pain should be tested by stimulation at the level of the limbs, because the grimacing associated with supraorbital or jaw-angle pressure may cause eye closure.

The presence of verbal responses indicates the restoration of a high degree of interaction with the environment (i.e., awareness). An oriented conversation implies awareness of the self (e.g., the patient can answer the question: "What is your name?") and environment (e.g., the patient correctly answers the questions: "Where are we?" and "What year/month is it?"). Confused speech is recorded when the patient is capable of producing language, for instance phrases and sentences, but is unable to answer the questions about orientation. When the patient presents intelligible articulation but exclaims only isolated words in a random way (often swear words, obtained by physical stimulation rather than by a verbal approach), this is scored as "inappropriate speech". Incomprehensible sounds refer to moaning and groaning without any recognizable words. This rudimentary vocalization does not necessitate awareness and is thought to depend upon subcortical functioning as it can be observed in anencephalic children and vegetative patients.

The motor response first assesses whether the patient obeys simple commands, given in verbal, gestural or written form. A non-specific sound stimulus may induce a reflex contraction of the patient's fingers or alternatively such a reflex response can result from the physical presence of the examiner's fingers against the palm of the patient (i.e., grasping reflex). Before accepting that the patient is truly obeying commands, it is advised to test that the patient will also release and squeeze again to repeated commands. If there is no response a painful stimulus is applied. First, pressure is applied to the fingernail bed with a pencil. If flexion is observed, stimulation is then applied to other sites (applying pressure to the supraorbital ridge, pinching the trapezium or rubbing the sternum) to differentiate between localization (i.e., a noxious stimulus applied at more than one site causes a limb to move so as to attempt to remove it by crossing the midline), withdrawal flexion (i.e., a multi-centric study of head-injured patients, assessment of each of the three components of the GCS was possible only in 56% on arrival in the neurosurgical unit, and in 49% in the "post-resuscitation" phase (Murray et al., 1993). In Glasgow, patients are always described by the three separate responses and never by the total (Teasdale et al., 1983).

*Glasgow Liège scale*

A frequently expressed reservation regarding the GCS is its failure to incorporate brainstem reflexes. A number of investigators have disagreed with Teasdale and Jennett that spontaneous eye opening is sufficiently indicative of brainstem arousal systems activity and have proposed coma scales that include brainstem responses (Segatore and Way, 1992). Many coma scales that include brainstem indicators have been proposed (e.g., the Comprehensive Level of Consciousness Scale (CLOCS, Stanczak et al., 1984), the Clinical Neurologic Assessment Tool (Crosby and Parsons, 1989), the Bouzarth Coma Scale (Bouzarth, 1968), the Maryland Coma Scale (Salcman et al., 1981)...) but none has become widely used. These scales generally have been more complex than the GCS.

A simpler system is the Glasgow Liège Scale (GLS) (see Fig. 3). It was developed in 1982 in Liège and combines the Glasgow Scale with a quantified analysis of five brainstem reflexes: fronto-orbicular, vertical oculo-cephalic, pupillary, horizontal oculo-cephalic and oculo-cardiac (Born et al., 1982). The fronto-orbicular reflex is considered present when percussion of the glabella produces contraction of the orbicularis oculi muscle. The oculo-cephalic reflexes (doll's head) are scored as present when deviation of at least one eye can be induced by repeated flexion and extension (vertical) or horizontal neck movement (horizontal). If the reflexes are absent or cannot be tested (e.g., immobilized cervical spine), an attempt is made to elicit ocular motion by external auditory canal irrigation using iced water (i.e., oculo-vestibular reflex testing). With cold-water irrigation of the head at 30° elevation from the horizontal, the eyes deviate tonically toward the ear irrigated (horizontal). When cold water is injected simultaneously into both ear canals, the eyes deviate tonically downward; the reverse occurs with bilateral irrigation of warm water (vertical). The oculocardiac reflex is scored as present when pressure on the eyeball causes the heart rate to slow down. As for the GCS, the best response determines the brainstem reflex score (R). The selected reflexes disappear in descending order during rostral-caudal deterioration. The disappearance of the last, the oculo-cardiac, coincides with brain death.

*Pitfalls encountered when administering the GCS/GLS*

Inexperienced or untrained observers produce unreliable scoring of consciousness (Rowley and Fielding, 1991). In one study, one out of five health care workers were mistaken when asked to make judgments as to whether patients were "conscious" or "unconscious" (Teasdale and Jennett, 1976). Consciousness needs considerable skill to evaluate and the observer should be aware of the pitfalls. It is also well known that the preceding score of the patient frequently influences the examiner when rating the patient's present state of consciousness. It is therefore recommended to score in a "blinded" manner. Problems arise when the eyes are swollen shut (e.g., following periorbital edema, direct ocular trauma or facial injury) or paralyzed (e.g., neuromuscular blockade). In these circumstances the enforced closure of the patient's eyes should be recorded on his chart by marking "C" ( = eyes closed) (Teasdale, 1975). In deep coma, flaccid eye muscles will show no response to stimulation yet the eyes remain open if the lids are drawn back. Speechlessness may be due to causes other than unawareness (e.g., intubation via the oropharynx or through tracheostomy, orofacial fractures, edematous tongue, foreign language, aphasia, confusion or delirium). The evaluation of verbal responses is also biased when patients received sedatives or neuromuscular blocking agents, alcohol or are drug intoxicated or too young to speak. When the verbal score cannot be assessed a non-numerical designation of "T" ( = intubated) should be used (Marion and Carlier, 1994) and the total GCS score cannot be reported. Finally, motor responses cannot be reliably monitored in the presence of splint or immobilization devices or in cases of spinal cord, plexus or peripheral nerve injury. As and reliable observation of the patient's behaviors. These scales are supposed to be more sensitive than previous scales as they include a much larger number of items (e.g., Davis, 1991; Giacino et al., 1991; Coma/Near Coma Scale; Rappaport et al., 1992; Visual Response Evaluation, Coma Exit Chart, Freeman, 1996; CRS, Giacino et al., 2004). However, it must be noted that studies specifically aimed at providing empirical evidence for this theoretically superior sensitivity are often lacking.

The CRS-R by Giacino et al. (2004) is a good example of those scales providing a more fine-grained assessment of the recovery of consciousness. The basic structure is similar to the GCS; it includes similar visual, motor and verbal subscales as the GCS, but there are in addition three other scales: an auditory function scale, a communication scale and an arousal scale (see Table 1). Furthermore, the visual, motor and verbal subscales are much more detailed than is the case in the GCS. For example, the visual subscale assesses visual startle responses, eye fixation, eye movement, visual object localization, and object recognition. These items are critical for identifying subtle signs of recovery of consciousness as discussed in the previous sections. Furthermore, for each item, fully operational definitions are provided and special importance is given to the consistency of behaviors assessed via the establishment of baseline observations and repeated administration of the item. This two-step procedure (baseline observation followed by repeated administration of a given item) permits greater certainty that a given behavior is not simply random or reflex, but that it is contingent upon a given stimulus. Inter-rater agreement and test–retest reliability are high for total CRS-R scores, and good concurrent validity is observed in relation to other scales such as the CRS and the Disability Rating Scale (Giacino et al., 1991, 2004, this volume). Furthermore, the CRS-R has been designed to be particularly helpful for discriminating between vegetative and minimally conscious state. As can be seen in Table 1, a number of specific items are proposed that should permit discrimination between vegetative and minimally conscious state (e.g., the observation of item 2 (fixation for more than 2 sec) on the visual function scale is supposed to be incompatible with a diagnosis of vegetative state but supports a diagnosis of minimally conscious state).

Table 1. JFK coma recovery scale — revised

| |
|---|
| *Auditory function scale* |
| 4 — Consistent movement to command[a] |
| 3 — Reproducible movement to command[a] |
| 2 — Localization to sound |
| 1 — Auditory startle |
| 0 — None |
| *Visual function scale* |
| 5 — Object recognition[a] |
| 4 — Object localization: reaching[a] |
| 3 — Pursuit eye movements[a] |
| 2 — Fixation (>2 sec)[a] |
| 1 — Visual startle |
| 0 — None |
| *Motor function scale* |
| 6 — Functional object use[b] |
| 5 — Automatic motor response[a] |
| 4 — Object manipulation[a] |
| 3 — Localization to noxious stimulation[a] |
| 2 — Flexion withdrawal |
| 1 — Abnormal posturing |
| 0 — None/flaccid |
| *Oromotor/verbal function scale* |
| 3 — Intelligible verbalization[a] |
| 2 — Vocalization/Oral movement |
| 1 — Oral reflexive movement |
| 0 — None |
| *Communication scale* |
| 2 — Functional (accurate)[b] |
| 1 — Non-functional (intentional)[a] |
| 0 — None |
| *Arousal scale* |
| 3 — Attention |
| 2 — Eye opening without stimulation |
| 1 — Eye opening with stimulation |
| 0 — Unarousable |

Adapted from Giacino et al. (2004).
[a]Indicates a minimally conscious state. [b]Indicates emergence from the minimally conscious state.

Some other scales have been explicitly designed for assessing minimal changes of recovery in response to sensory stimulation treatments and are supposed to be particularly sensitive for detecting subtle changes in the level of consciousness, and are therefore also very helpful for discriminating between vegetative state and minimally conscious state, even if these scales do not explicitly

Table 2. Sensory Modality Assessment and Rehabilitation Technique hierarchical scale for sensory modalities and their comparison to Rancho levels

| SMART level | SMART response | Rancho levels |
|---|---|---|
| 1 | *No response*<br>To any stimulus | *I No response*<br>In deep sleep and unresponsive to stimuli |
| 2 | *Reflex response*<br>To stimuli reflexive and generalized responses, i.e. startle, flexor or extensor pattern | *II Generalized response*<br>Reacting inconsistently and non-purposefully to stimuli |
| 3 | *Withdrawal response*<br>To stimuli may, for example, turn head or eyes away or withdraw limbs from stimulus | *III Localized response*<br>Patient reacts specifically but inconsistently to stimuli |
| 4 | *Localizing response*<br>To stimulus may, for example, turn head or move upper limbs toward stimuli | III |
| 5 | *Differentiating response*<br>Patient may, for example, follow visual or auditory commands or use object appropriately | *IV Confused-agitated*<br>And subsequent Rancho levels |

Adapted from Gill-Thwaites and Munday (2004).

between observers[1]; modest, although significant correlation was established between SMART and either physician or WNSSP scores. A total of 45% of subjects diagnosed to have been in vegetative state by the referring physician on admission demonstrated awareness of self and the environment. Of these subjects, 28% demonstrated this behavior within week 1 of admission. While this figure does not take account of those patients who required time to enable the staff to become familiar with the patient and to fully stabilize the patients' medical status, it is clear that the rate of misdiagnosis may have been greater. The research indicates that the SMART is a valid and reliable assessment for discriminating awareness in vegetative state and minimally conscious state. The SMART therefore provides a reliable and valid tool, which enables the assessor to establish consistency, quality, and meaning of specific responses within each sensory modality to specifically define evidence of awareness and discriminates vegetative from minimally conscious and higher level functioning patients.

[1]It must be noted that there is somewhat greater variation among the scores when considering the different subscales separately, but as the composite score is the relevant measure, the reliabilities reported here accurately reflect the performance of the scale.

The WHIM, developed by Shiel et al. (2000) and based on previous work by Horn et al. (1992, 1993) and Wilson et al. (1994), was created by observing the behaviors that occurred spontaneously or in response to stimulation in a large cohort of initially comatose patients followed longitudinally over time. Following this initial phase of empirical observation, 145 behaviors were identified. These 145 behaviors were then categorized into six subscales (communication, attention, social behavior, concentration, visual awareness, and cognition) which were then assembled to form a single main scale of 62 items. Most importantly, these 62 items are ordered in a hierarchical way, the hierarchy of behaviors assessed reflecting a statistically derived order of recovery from coma: item 1 should appear before item 2, item 2 before item 3, etc. To obtain this hierarchy, the behaviors were ranked a posteriori as a function of order of appearance observed during recovery, using a paired preference technique, similar to the paired comparisons technique often used for the construction of ordinal scales (Watson and Horn, 1992; Watson et al., 1997). The WHIM score represents the rank order of the most advanced item observed (rather than adding the different items observed). The WHIM was designed to monitor all stages of recovery from coma to emerging post-traumatic amnesia, to monitor subtle changes in patients in a minimally that will make impossible the scoring of a number of items needing a given sensory or motor modality. This is particularly important as these sensory and motor impairments are a frequent cause of misdiagnosis. In these cases, the use of individualized assessment techniques is recommended. For example, Whyte et al. (1995, 1999) proposed a method for a reliable assessment of visual attention and command following in these patients (see also Giacino and Whyte, 2005). The principle of this method is to find, for an individual patient, at least one behavior with which the patient seems to produce voluntary responses. This behavior is likely to be different in each patient and depends on his particular sensory and motor impairments. Once this behavior has been detected, the second aim is to determine whether this behavior is really voluntary, by determining the baseline frequency of this behavior, and by determining increases in frequency of this behavior over time and as a result of stimulation (e.g., on command). In order to consider a behavior as volitional, the patient has to respond more frequently when required to produce the behavior than during baseline and he must respond less frequently when instructed not to produce the behavior. This method permits to obtain discrimination scores between the three conditions (behavior on, behavior off, baseline) for which statistical significance can be tested. Using such individualized assessment methods in combination with the standardized assessment scales presented above, both the sensitivity and reliability of behavioral assessment of altered states of consciousness is likely to be maximized. The CRS-R has incorporated parts of these individualized assessment techniques as described by Whyte et al. (1997, 1999).

As obvious time constraints in the clinical setting will not allow to assess every patient with each of the presented scales, we will conclude this section by providing some guidelines for selecting the most appropriate scale, depending on the question that is asked and the state the patient is in. In the acute setting, the GCS remains the "gold standard" in the evaluation of coma. By virtue of its simplicity, it is the most universally utilized consciousness scale worldwide and seems, despite its drawbacks, destined to be used in emergency medicine and intensive care for some time. In the post-coma phase, and to differentiate between vegetative and minimally conscious state, the CRS-R (Giacino et al., 2004), in conjunction with the individualized assessment technique proposed by Whyte et al. (1995, 1999), might be the best solution as it was specifically designed for making this differential diagnosis. When following a patient longitudinally and documenting subtle progresses in the recovery of consciousness, the SMART and WHIM could be more appropriate. The WHIM seems more practical for assessments made on a daily basis as time needed to administer this scale is only about 10 min (range 2–35 min), while administration of the SMART takes between 30 and 40 min. The WHIM has been shown to be particularly sensitive for patients in the minimally conscious state and patients showing slow but relatively good recovery. On the other hand, one important advantage of the SMART is that it also assesses responses to a sensory stimulation program, which is not the case for the other scales. Finally, the SMART appears to be particularly suitable for patients in the vicinity of the vegetative state. Although the WHIM also shows a good sensitivity for this state, the inclusion of an olfactory function subscale in the SMART provides an additional opportunity for detecting subtle signs of responsiveness.

## Conclusions

Assessment of awareness is not a matter of all or nothing. Recovery of awareness is a very gradual process, with sometimes great leaps forwards, but more often subtle changes, and also sometimes setbacks. For the patient emerging from coma, it is of utmost importance that the medical staff adapts its assessment to the level of awareness the patient is currently in. The subtlest signs of awareness, as well as their fluctuation, have to be reliably captured as they are the only means for avoiding misdiagnosis, but also for communicating with these patients. This implies the use of standardized, sensitive and individualized assessment tools that cover a wide range of possible, although sometimes minimal, behaviors in all sensory modalities. The major challenge of the years to come will not be to develop new tools, but to effectively implement

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