The Sensory Stimulation Assessment Measure (SSAM): a tool for early evaluation of severely brain-injured patients

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There has been little definitive research on the efficacy of sensory stimulation, yet many brain-injury rehabilitation programmes offer some form of it as treatment for severely injured patients. In general, however, sensory stimulation programmes and outcome studies alike lack precise definitions of terms, consistent criteria of patient selection, and valid and reliable measures of response to treatment. The Sensory Stimulation Assessment Measure (SSAM) was developed as a neuropsychological approach that provides a reliable and valid measure of responsiveness in patients who can neither communicate nor consistently follow commands. Patient responses are divided into three six-point behavioural scales (Eye Opening, Motor, and Vocalization) that require little evaluator subjectivity or inference. The measure may be used in treatment planning and is designed to address the rigorous demands of scientific research. Validity, reliability, and normative data are presented.

Introduction

Sensory stimulation is an integral part of the programmes of many rehabilitation hospitals and skilled nursing facilities that treat patients in coma and coma-emerging conditions. As any clinician who works with severely brain-injured patients knows, the normal clinical routine of treating a person (e.g. examinations, nursing care, various therapies, even family visits) also results in stimulation.

At times, highly dramatic results have been claimed by proponents of different methods of stimulation. As a result there is great interest in approaches to determining whether the structured use of sensory stimulation indeed has any effect on patients, and how those effects can be measured reliably. For example, what are the outcomes of these types of patients, what sort of formal stimulation or withdrawal from stimulation did they receive, and which other processes that occurred during treatment may also have contributed to those outcomes?

One approach that addresses these issues is the Sensory Stimulation Assessment Measure (SSAM) [1], which was developed as a tool for measuring the unconscious patient over a long period of time. Although the SSAM has already been cited in the literature (sometimes including erroneous interpretations), the authors have not previously published any formal report about its use and efficacy. Besides presenting an overview of the current literature on sensory stimulation, this article is designed to remedy that situation.

A major goal of sensory stimulation is to shorten the duration of the unconscious state. The underlying theory is that the patient's subcortical connections are in some
sense ‘not firing’, or are working at reduced efficiency, and that stimulation may therefore provide arousal procedures for pathways that are compromised but not destroyed. Of course, stimulation procedures should be used in conjunction with standard practices of good rehabilitative medical care [2].

Sensory stimulation interventions are usually based on one or more of the following assumptions:

1. Environmental stimulation can help prevent sensory deprivation [3].
2. The periodic monitoring associated with sensory stimulation can provide a method of evaluating the patient’s clinical progress.
3. Some studies have shown that sensory stimulation programmes have a therapeutic effect.
4. Sensory stimulation provides a structured system of intervention in which family members can participate [4].

As noted above, relatively little formal research on the effectiveness of sensory stimulation has been carried out until recently. However, as attention is increasingly focused on this method of intervention, a growing body of data is becoming available.

In one of the first reports, LeWinn and Dimancescu [5] claimed that early and intensive provision of stimuli can enhance the rate of recovery from coma and can promote ‘synaptic reinnervation’. They reported on a group of 16 patients with initial Glasgow Coma Scale (GCS) [6] scores of 3, 4, or 5. Coma was related to head injury (10 patients), hypoxia (four patients), or brain tumours with prolonged unconsciousness (two patients). Programmes of ‘environmental enrichment’ (i.e., stimulation) were initiated within 12–24 hours of admission to the hospital. Follow-up showed that there were no deaths and that all 16 patients ‘fully recovered’ from coma. These patients were compared to a group of 14 patients with similar GCS scores who had not undergone the environmental enrichment programme. Eleven of the patients who had not received the environmental enrichment programme died.

Mitchell et al. [7] evaluated the efficacy of a ‘coma arousal’ procedure, using two comparable groups of 12 patients treated for severe brain injury. Patients in the control group were not subjected to any arousal procedure, whereas coma-arousal procedures were initiated for patients in the experimental group. Sensory stimulation consisted of auditory, tactile, olfactory, taste, and visual stimuli provided in 1-hour cycles once or twice a day. Coma duration for patients in the experimental group was found to be significantly shorter than that of patients in the control group. These results suggest that using a coma-arousal procedure as a standard technique very early in the treatment of severe head injury may facilitate more rapid recovery.

Along similar theoretical lines, Hall et al. [8] conducted a pilot study using an ABAB design with six subjects at GCS 3 to GCS 7 who were only 2–3 weeks post-injury at the onset of the study. They compared best responses to directed multisensory stimulation with best responses to non-directed stimulation. Specific directed stimulation involved input directed at the subject’s level of functioning, whereas non-directed stimulation was designed to simulate the general sensory input in a general hospital.

They found that, over the course of treatment, directed multisensory stimulation elicited responses that might not typically be seen in the normal course of the subject’s day. They also reported that four of the six subjects ultimately progressed to active head injury rehabilitation, and one became ambulatory and independent in ADLs in a long-term care facility. However, their research design made it difficult to attribute these outcomes to directed multisensory stimulation.
Kater [9] studied 30 brain-injured patients admitted to the rehabilitation services of two hospitals. As in the other studies cited, patients were matched according to sex, age, type of injury, and GCS score. Outcome was measured by the patients' level on the Rancho Los Amigos Levels of Cognitive Functioning (Rancho Level) [10] 3 months after the injury. Kater found that patients who had received controlled sensory stimulation had achieved a higher cognitive level than patients who received only nursing care and physical therapy.

Wilson et al. [11] studied four patients with initial GCS scores of 8 or less who ranged in time-since-injury from 2 to 22 months. Individually designed programmes of multimodal sensory stimulation resulted in significant changes in post-stimulation behaviour in all four patients. These changes included increased frequency of eye-opening as well as an increase in spontaneous body movements while the eyes were open. The researchers concluded that multimodal sensory stimulation had the desired effect in the short term, but they could not draw conclusions about its longer-term effects.

Wood et al. [12] conducted a pilot study comparing the outcomes of four patients treated in a 'sensory regulated environment' with four patients who were 'exposed to sensory stimulation of an unregulated kind'. The four control patients were selected retrospectively from hospital files prior to the reported study, whereas the four experimental subjects were selected from current admissions. Subjects were matched on age, injury, response level, and time since injury (range was 31–71 days). As in the Hall et al. [8] study, Wood et al. [12] took care to fit the treatment regimen to the processing characteristics of each subject in the experimental group, while the individual ability to process information was not considered for members of the control group. All four of the experimental subjects were reported to have progressed into an acute rehabilitation setting, as compared with only one from the control group. The remaining three controls returned home, where they required 'total care'. Because sampling procedures for obtaining subjects were not described, these results are difficult to interpret.

Rader et al. [13] followed 20 patients who were administered a 3-month trial of sensory stimulation in addition to intensive interdisciplinary rehabilitation. These patients averaged 12.4 months post-injury, with a range of 2–33 months. The study compared patients' overall responsiveness at baseline and after 3 months, and found no differences between the two values. The authors concluded that although certain treatment conditions were associated with better immediate responses to stimulation, their research did not support the efficacy of sensory stimulation for severely brain-injured patients greater than 6 months post-trauma.

Pierce and colleagues [14] evaluated the effectiveness of a coma-arousal programme administered to a pilot group of 31 patients who were unable to obey a simple command 2 weeks after sustaining a severe brain injury. Non-standardized multisensory stimulations were administered by the patients' families for up to 8 hours a day, 7 days a week. A reference group [15] of 135 patients was used for comparison. Forty-two per cent of patients in the coma arousal group achieved a rating of 'moderate disability' or 'good recovery' on the Glasgow Outcome Scale (GOS) [16], whereas 31% of patients in the reference group achieved similar outcomes. This difference was not statistically significant, and the researchers concluded that outcomes associated with sensory stimulation were not dramatically better than outcomes achieved with conventional medical management.

A significant problem with coma-arousal research is that outcome is heavily
dependent on the sensitivity of the instrument used. The Glasgow Outcome Scale (GOS) [16] is a useful tool for epidemiological studies of populations of patients, or indeed samples of patients, but is totally insensitive as a measure of individual clinical change. In the Pierce study and its reference study [15], success was measured by the GOS, a five-point scale on which outcome is scored from 1 (death) to 5 ('good recovery'). It is often condensed into a two-part scale indicating 'good' outcomes (incorporating 'moderate disability' and 'good recovery') and 'bad' outcomes (death, 'persistent vegetative state', and 'severe disability'). What hinders the accurate application of either of these versions of the GOS is that the term 'severe disability' is used to describe a broad range of behaviour and cognitive abilities. For example, severe disability is often used to describe patients who are dependent for daily support by reason of mental or physical disability, usually a combination of both. Many are in institutions, but exceptional family efforts can result in their being cared for at home. This category includes patients who may perform activities of daily living limited to their room or house. However, it also includes patients who can only follow simple commands, who move purposefully, or who track objects around their room [16]. In much sensory stimulation research these outcomes are seen as equivalent.

Our own ongoing research highlights this problem. A preliminary sample of 50 patients who were initially diagnosed at Rancho Level I or II when enrolled in a sensory stimulation programme in a coma-rehabilitation unit did not consistently follow commands or communicate. Time from injury to programme admission ranged from 3 weeks to 38 months. Following structured sensory stimulation and interdisciplinary rehabilitation therapy, over half demonstrated responses indicative of measurable cognitive functioning (e.g. they answered questions correctly using simple yes/no responses), and 30% ultimately achieved a Rancho Level of V or higher. However, if the GOS were used, 90% of this group would still be classified as having obtained a poor outcome (i.e. severe disability or worse). The implications for sensory stimulation efficacy may appear radically different, then, depending on the sensitivity of outcome measure selected.

The Sensory Stimulation Assessment Measure

As noted above, there have been few formal, reliable procedures for assessing the functioning of severely brain-injured individuals. Furthermore, even these procedures rarely show demonstrable sensitivity to the shifts in patient function that are often noted clinically. Interpretation of sensory stimulation studies is difficult because of inadequate standardization of methods and consequent doubt regarding the reliability of the data. The Sensory Stimulation Assessment Measure (SSAM) [1] was developed as a neuropsychological approach that provides a reliable, valid, and sensitive assessment of patients who can neither communicate nor consistently follow commands. It is intended not only to assist in treatment planning but also to address the rigorous demands of scientific research.

The SSAM standardizes the stimulation and quantifies patient responsiveness. One person (the stimulator) provides the stimulation and another person (the rater) can be used to assess the responses. This procedure minimizes the problem of observer bias. The response scales elaborate upon the three dimensions of the Glasgow Coma Scale [6]: (1) eye opening, (2) motor response, and (3) vocalization. However, the SSAM response scales extend beyond command-following.
**Definition of Responses**

<table>
<thead>
<tr>
<th>I. Eye Opening</th>
<th>II. Motor</th>
<th>III. Vocalization/Verbalization</th>
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<tbody>
<tr>
<td>1. No changes in eye opening: When compared with baseline eye opening behavior, no changes occur as a result of stimulation.</td>
<td>1. No motor response: No discernible change in motor activity from baseline levels as a result of stimulation.</td>
<td>1. None: Patient produces no auditorially discernible sounds by mouth as opposed to tracheostomy exhalation, congestion, etc. or heavy breathing.</td>
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<tr>
<td>2. Eye opening in response to stimulation only: Patient's eyes are predominantly closed during baseline. Stimulation results in increases in eye opening.</td>
<td>2. Change in tone (passive tone or extremity movement in pattern lasting less than 10 sec), facial grimace or oral movements: Automatic increases or decreases in muscle tone. This response to sensory input is a static change, the trunk or extremity feels different to the examiner after stimulation (e.g. more rigid or floppy). Any facial grimacing and/or oral movements (e.g. tongue movements, swallowing, lip smacking).</td>
<td>2. Vocalization generated either alone or in the presence of others: This includes moans, groans, cries or sounds.</td>
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<tr>
<td>3. Visual tracking &lt; 3: Eye movements toward stimulus (patient appears to be “looking at” stimulus and/or stimulator) for less than 3 sec.</td>
<td>3. Active initiation of movement (e.g. sustained movement of head or extremities): Changes in posture or positioning as a product of patient's active efforts. Patient turns head toward or away from stimulation.</td>
<td>3. Vocalization in response to structured stimulation: Moans, groans, cries or sounds that increase in intensity, frequency, or duration over baseline levels as a response to stimulation.</td>
</tr>
<tr>
<td>4. Visual tracking &gt; 3: Eye movements toward stimulus (patient appears to be “looking at” stimulus and/or stimulator) for more than 3 sec.</td>
<td>4. Purposeful movement of extremity toward stimulation: Patient appears to demonstrate volitional control of extremity; moves extremity toward stimulation or stimulator.</td>
<td>4. Vocalization and verbalization in response to structured stimulation: Sounds or vocalizations that appear to resemble language (e.g., contain vowels and consonants) but do not constitute intelligible language.</td>
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<td>5. Blinks, opens or closes eyes in response to commands to do so at least 2 of 3 trials.</td>
<td>5. Following commands: Patient moves body parts in response to commands to do so at least 2 of 3 trials.</td>
<td>5. Intelligible verbalization resembling speech sounds in response to structured stimulation, questions or commands: Patients productions are understandable at least 30% of the time.</td>
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<td>6. Correctly answers simple questions: Patient uses eye movements (e.g. closing, opening, blinks) to communicate yes/no.</td>
<td>6. Extremity movement as communication response to a simple question: Patient uses extremity movement to communicate yes/no.</td>
<td>6. Clear, intelligible verbalizations (e.g., able to communicate an idea): May be perseverative, tangential, rambling or use improper words. Productions are understandable between 30% and 80% of the time.</td>
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**Figure 1. The SSAM Response Scale: definition of responses.**
The SSAM consists of standardized stimuli to five senses—sight (visual), hearing (auditory), touch (tactile), taste (gustatory), and smell (olfactory). The protocol includes only procedures in which no invasive, noxious, or painful stimuli are used. Each sensory input stimulation procedure consists of graded stimuli and ends with questions about the stimulus itself. The questioning procedure differentiates between accurate responding and positive and negative response sets. The stimulation protocol and the response scales were designed with considerable input from experienced rehabilitation professionals in the fields of physical therapy, occupational therapy, speech/language pathology, nursing, and neuropsychology.

Each response scale is hierarchically arranged to be sensitive to a range of behaviour commonly seen in a severely neurologically impaired population. The lowest value is assigned to responses that reflect no change from baseline behaviour. The highest value represents a demonstration of the patient's ability to use eye-opening, motor, and vocalization behaviour as communication with acceptable reliability and consistency.

Administration of the SSAM

To administer the SSAM, a team of two (a stimulator and a rater) or a stimulator alone first conducts a 5-minute observation period during which spontaneous behaviour is recorded. This is then used as a baseline against which behavioural responses to stimulation are compared. The patient is then aroused, if necessary, by rubbing a wet cloth filled with ice chips over the head and face for 30–60 seconds, and the patient's name is called repeatedly until his or her eyes are open. The procedure is then introduced to the patient in simple, clearly articulated language. The patient is told that nothing is meant to harm him or her, and is asked to try as hard as possible to do what he or she is asked to do.

Following this orientation, auditory stimulation is begun. The goal of this and the initial phase of visual stimulation is to identify the patient's ability to demonstrate volitional control of response. He or she is asked to follow a series of motor-movement and eye-opening commands that are presented first auditorially and then visually. The most consistent command-following response (e.g. eye-blinks, finger movement) is identified through a series of trials requiring two of three correct responses. The patient is then tested throughout the procedure for yes/no communication value in answering questions about visual, smell, taste, and tactile stimulation. If command-following is not demonstrated, the best response to stimulation (see Figure 1) in all response categories is recorded.

Following the evaluation of auditory and visual command-following, the assessment procedure may be temporarily halted for a 30-minute break, or it may continue, depending on the patient's endurance. Our standardization research has demonstrated that split-administration scores were nearly identical to those of one single administration of the procedure.

Visual tracking response to light, consensual light reflex, and eye-blinking to confrontation are then assessed. If command-following was present, visual materials (common objects and colours) are presented, and the patient is asked four simple yes/no questions about the stimuli. Two questions require a 'yes' response, and two require a 'no'. Positive or negative response sets (all 'yes' or all 'no' answers) are scored as command-following only. The same procedures are followed for olfactory stimulation (strawberry, almond, and orange extracts), gustatory stimulation (chocolate, baking
soda, and lemon extract), and tactile stimulation (hot and cold). Scores are recorded, plotted, and totalled. Subscores are available for Total Eye Opening, Motor, and Vocalization values, as well as totals for each of the five sensory areas. A General Responsiveness score is calculated based on these subscores.

Figure 2 represents the SSAM summary of scores and results of command-following and question tasks.

Reliability, validity, and normative data

Method

Twenty patients who showed definite sleep-wake cycles but who neither followed commands consistently nor communicated with others at the initiation of the procedure were selected for the standardization studies from an available pool of 26 patients. Exclusion was due either to medical instability or ventilator dependence. Subjects' ages ranged from 16 to 59, with a mean age of 31 years. Fourteen patients had severe closed-head injuries which were due to motor vehicle accidents, falls, or industrial accidents. Other patients had suffered hypoxia or anoxia (three patients); aneurysms (two); and a gunshot wound (one). The average time since injury was 12.4 months, with a range of 2-33 months. Socioeconomic status ranged from lower class to upper-middle class. Sixteen (80%) had at least a high school education, and eight of those had attended college.

Inter-rater reliability. To obtain inter-rater reliability, the SSAM was administered as previously described to each of 19 subjects once between the hours of 1 and 4 p.m. (One subject from the original 20 had been transferred due to medical instability.) The overall procedure took an average of 45-50 minutes. Two raters simultaneously but independently observed and evaluated responses to stimulation. A total of five raters were used in random pairs; all had been trained in the use of the response scales. This training, which lasted approximately 2 hours, consisted of instruction in scoring procedures, actual demonstrations by the authors, and discussion to resolve scoring questions. Completed protocols were scored by each evaluator and totalled independently by the investigator without consultation. General responsiveness scores were obtained and then correlated using the Pearson method (Table 1).

Table 1 presents inter-rater reliability values. Considering the small sample size (n = 19), the r = 0.89 value was quite high and statistically significant. Widely disparate scores between raters (more than three total points) were rare, but did occur.

Test-retest reliability. To establish test-retest reliability the SSAM was administered to each subject twice, at approximately the same time of day within a 72-hour period. The overall procedure took approximately 50 minutes for each administration. Patients were in bed supine with their heads elevated at a 30-45 degree angle. Each patient was stimulated using a standard protocol emphasizing encouragement and verbal feedback. Evaluation teams of two research assistants were used. Each team consisted of the same stimulator and rater for both trials. In order to minimize rater bias, completed protocols were not scored until both trials had been conducted. A General Responsiveness (GR) score was obtained across five separate sense stimulations by summing the best responses on each of the following scales: eye opening, motor, and
Best Response to Stimulation

![Table of responses to stimulation]

**TOTAL SCORES**

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<th>Responses</th>
<th>Senses</th>
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<tr>
<td>I. Eye Opening</td>
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<td>II. Motor</td>
<td>Visual</td>
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<td>III. Vocalization</td>
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<td>Tactile</td>
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**GENERAL RESPONSIVENESS:**

**COMMAND FOLLOWING**

<table>
<thead>
<tr>
<th>Auditory Stimulation</th>
<th>Visual Stimulation</th>
<th>Eyes</th>
<th>Visual Stimulation</th>
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<td>Yes</td>
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**Questions**

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<th>Color</th>
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**Notes:**

![Figure 2. The SSAM summary of scores.]

Figure 2. The SSAM summary of scores.
vocalization/verbalization. These scores were then correlated using the Pearson method, to yield a test–retest reliability coefficient (Table 2).

Table 2 presents test–retest reliability values for 20 patients. SSAM General Responsiveness mean scores were equivalent ($\bar{x}_1 = 28.55, SD_1 = 10.46$; $\bar{x}_2 = 29.40, SD_2 = 10.70$). Ranges of scores were similar (trial 1: range of $x = 16–61$; trial 2: range of $x = 17–60$). These results suggest that there was no temporal group effect from the first administration to the second as well as consistency of individual scores over the 72-hour time period.

Concurrent validity. To assess concurrent validity the Glasgow Coma Scale [16], Rancho Los Amigos Cognitive Scale [10] and the Disability Rating Scale [17, 18] were completed for each subject. Therapy and nursing staff reports of the best response were used when there was doubt about actual response levels. Subjects were rated independently by two evaluators, and discrepancies were discussed; agreement was reached in all cases. Validity coefficients were established by obtaining the mean of the Sensory Stimulation General Responsiveness values, and then calculating Pearson $r$ values with scores on each of the three scales (Table 3).

Interpretation. Like any assessment instrument, the SSAM is based on the standardized observation of behaviour. However, in order to capture the richness of information available in patient behaviour, both quantitative measurement and qualitative interpretation must be integrated. No single score or index value can take the place of a systematic interpretive approach to the data. Several separate approaches are recommended to interpreting performance. This use of multiple strategies is the same approach recommended by others for the interpretation of neuropsychological test data.

The SSAM provides a useful framework for observing patient behaviour in terms of (1) level of performance, (2) response output scale and sensory input patterns, (3) right–left differences, and (4) pathognomonic signs.

Level of performance. The SSAM has been designed to provide quantitative data for both clinical and research use. The General Responsiveness value establishes an overall level of performance. Normative research has shown that the General Responsiveness values for patients at Rancho Levels II, III–IV, and V form relatively discrete distributions. For example, the mean GR value at Rancho II is 21.6 (SD 4.69). Given the normal distribution of SSAM scores (median 21), this means that two-thirds of all Rancho Level II patients achieve a SSAM General Responsiveness score between 17 and 27. Likewise, two-thirds of all Rancho III–IV patients earned a General...
Table 2. Test-retest reliability (n = 20)

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\[ r_{xy} = 0.93^* \]

\[
\begin{align*}
\hat{x} &= \text{first administration} \\
\bar{x} &= 28.55 \\
S_x &= 10.46 \\
\text{range} x &= 16-61
\end{align*}
\]

\[
\begin{align*}
y &= \text{second administration} \\
\bar{y} &= 29.401 \\
S_y &= 10.70 \\
\text{range} y &= 17-60
\end{align*}
\]

\*\(p<0.01\) (d.f. = 19).

Table 3. Concurrent validity: Sensory Stimulation Assessment Measure with Glasgow Coma Scale (GCS), Disability Rating Scale (DRS), and Rancho Los Amigos Scale (RLA)

<table>
<thead>
<tr>
<th>Assessment Measure</th>
<th>GCScale</th>
<th>DRS</th>
<th>RLA Cog. Function</th>
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<tbody>
<tr>
<td>(\hat{x} = 28.98)</td>
<td>(\bar{y} = 8.5)</td>
<td>(\bar{z} = 23.3)</td>
<td>(\bar{w} = 2.3)</td>
</tr>
<tr>
<td>(S_x = 10.40)</td>
<td>(S_y = 1.12)</td>
<td>(S_z = 1.87)</td>
<td>(S_w = 0.43)</td>
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<tr>
<td>(\text{range} \ x = 17-60.5)</td>
<td>(\text{range} \ y = 6-10)</td>
<td>(\text{range} \ z = 26-19)</td>
<td>(\text{range} \ w = 2-3)</td>
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<tr>
<td>(n = 20)</td>
<td>(n = 20)</td>
<td>(n = 20)</td>
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<tr>
<td>(r_{xy} = 0.70)</td>
<td>(r_{xz} = -0.61)</td>
<td>(r_{yw} = 0.68)</td>
<td>(p&lt;0.01) (d.f. = 19)</td>
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<td>(p&lt;0.01) (d.f. = 19)</td>
<td>(p&lt;0.01) (d.f. = 19)</td>
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Responsiveness value between 30 and 45 (mean 37·23, median 37). Additionally, two-thirds of all Rancho Level V patients who were tested scored between 47 and 72 (mean 59·72, median 57).

A one-way analysis of variance was performed on SSAM GR scores of 85 patients in either Rancho Level (RL) II, III–IV, or V according to the following criteria: (1) RL II—patient responds inconsistently and nonpurposefully, does not follow commands or demonstrate purposeful movement; (2) RL III–IV—patient inconsistently follows commands and/or engages in purposeful behaviour; (3) RL V—patient follows simple commands and accurately answers yes/no questions about the stimulation itself. The results indicated significant differences between groups and demonstrated that the SSAM differentiates clearly between these levels of cognitive function (see Table 4).

Although reached in very different ways, Rancho Level (qualitative) and SSAM General Responsiveness score (quantitative observation under controlled conditions) correlate 0·68. This lends support to the claim that a particular patient's General Responsiveness score provides information about his or her overall cognitive functioning.

Because the subscales consist of the best responses obtained for each sensory modality, the scores reflect the patient's maximum capability. Individual SSAM subscores also correlate with Rancho Levels for sensory input as well as response output categories.

The profile of best responses can be used to assist in diagnosing cognitive level and in treatment planning. Specific information is obtained regarding the presence of purposeful behaviour, command-following, and answering questions.

Response output scale and sensory input patterns. Examination of subscale scatter among eye-opening, motor, and vocalization values gives useful information about the most reliable mode of responding, as well as alternative ones. The SSAM requires the
examiner to explore all available modes of responding before the most reliable is identified. In some cases it is a straightforward decision (e.g. the patient may speak to you, or only use eye-blink reliably). Patients may have multiple response capabilities (e.g. hand movements, eye blinks, and head nods). The evaluator needs to observe whether scale values cluster together and yield an even profile, or whether one response is favoured over others. If so, can the patient use more than one response, or is he or she limited to one or two? This information is useful for developing communication systems, as well as for identifying responses within the patient’s voluntary control.

Consistency of response output should also be systematically explored. Does a behaviour occur once or twice, or regularly? Are there differences between the best response and the most frequent one? Does the patient demonstrate the same level of response with everyone, or do some people (e.g. family members) elicit more (or less) consistent and stronger (or weaker) responses? If the patient is capable of answering questions, does he or she answer all questions accurately, or just some of them?

In the same way that analysis of response output can yield useful information, examination of sensory input variability can help the examiner identify the best-functioning input channels. Are responses consistently higher for one sense over others? Is one input channel particularly weak or variable? Are there patterns of failures, or lower than expected responses (e.g. olfactory only, or colour only) that might be of clinical significance? For example, does a patient follow written commands but not spoken ones? Can he or she accurately answer questions about taste but not about hot or cold?

**Right–left differences.** Simple observation and evaluation of right–left differences is an important part of the interpretive process. Sensitivity to input of auditory, visual and tactile stimuli on the right and left side of the body should be observed and recorded. This information is useful for immediate rehabilitation planning. Sensory deficits might be due to insult to primary sensory areas in the cerebral cortex, or to peripheral neuropathy. Right–left differences in pupil size or pupillary reactions to light often signal moderate to severe contusion, haematoma, or both.

Information about visual fields and tracking ability is also useful in determining which side to approach a patient from, and where to stand when working with him.
or her. Additionally, motor responsiveness of the right and left extremities is diagnostically important and should be recorded.

(Pathognomonic signs.) The SSAM is meant to be used in conjunction with the standard neurological and/or physiatric examination. In both approaches, certain signs are significant.

During the ocular–cranial nerve assessment section, anomalies in responses to light, blink reflex, and tracking are particularly useful in assessing the intactness of cranial nerve function and the possibility of elevated intracranial pressure. Pupils that are bilaterally unreactive for more than a few hours are almost always a sign of severe brain dysfunction [19].

Visual inspection of the patient can give information about tremors, rhythmic or involuntary motor behaviour, and abnormalities of tone. Decorticate posturing, in which the upper extremities are flexed and lower extremities are extended, is associated with lower thalamic damage. Decerebrate posturing, in which both upper and lower extremities are rigidly extended, generally reflects midbrain structural damage; deeper brainstem damage results in muscle flaccidity [20].

Conclusions

The SSAM is a valid and reliable test of overall responsiveness as well as input and response strengths and weaknesses of individual patients. This tool can be used for the following purposes: (1) to establish pretreatment baselines of behaviour and responsiveness; (2) to plan patient-specific treatment; (3) to monitor patient change over time; (4) to monitor the effectiveness of various interventions (e.g. coma stimulation, surgical procedures, medications, therapies); (5) to provide early indications of later neuropsychological deficits; and (6) to provide family members with objective information and some direction for their own efforts at intervention with the patient.

Because the measure provides quantitative as well as qualitative data, it is useful for research. It is especially well-suited for research designs employing a variety of statistical procedures. Some examples of research uses include (1) studying the effectiveness of experimental treatment approaches; (2) tracking the rate of recovery of individual patients or diagnostic groups of patients; and (3) predicting outcome, in the sense that the measure can isolate early response patterns that may be associated with various recovery patterns.

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