Gill-Thwaites & Elliott Consultants
Specialists in Disorders of Consciousness

Loccate

LOCCATE MANUAL

Levels of Consciousness Calibration of Assessment Tools Evaluations

An innovation by Gill-Thwaites and Elliott Consultants

Helen L. Gill-Thwaites[a,b], Karen E. Elliott[a] and [c]Anne-Marie Morrissey

[a]Gill-Thwaites & Elliott Consultants, UK; [b]Royal Hospital for Neuro-disability, London; [c]School of Allied Health, Health Research Institute, Ageing Research Centre, University of Limerick, Ireland.

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Introduction

Standardised neurobehavioural assessment tools (SNBATs) form a key aspect of diagnostic assessment for individuals with prolonged disorders of consciousness (PDOC). Defining diagnostic and prognostic parameters requires collating multiple SNBAT results over time, which is problematic if several assessors and professions are involved. Individuals with varying levels of awareness and responsiveness are currently subdivided into the broad diagnostic categories of vegetative state (VS) and minimally conscious state (MCS). Since the publication of agreed diagnostic criteria for these states of consciousness (Giacino et al., 2002; Multi-Society Task Force, 1994), several SNBATs have been developed. The Glasgow Coma Scale (GCS) (Teasdale & Jennett, 1974) is the most commonly used scoring system to describe consciousness in the acute phase. Also frequently used to assess PDOC, as recommended by the Royal College of Physicians (RCP) in national guidelines (RCP, 2020), are the Wessex Head Injury Matrix – WHIM (Shiel et al., 2000), Sensory Modality Assessment and Rehabilitation Technique – SMART (Gill-Thwaites, 1997; Gill-Thwaites & Munday, 2004) and the Coma Recovery Scale-Revised – CRS-R (Giacino et al., 2004).

The Levels of Consciousness Calibration of Assessment Tools Evaluations (LOCCATE) is the first tool designed to calibrate the results of any recognised PDOC SNBAT. Current clinical and medico-legal practices suggest that less emphasis should be placed on PDOC diagnosis for decision-making. The ability to focus on and track changes in responses, incremental change within diagnosis and the trajectory change over time, and to combine the information gained from multiple assessments, is ever more important as an evidence base to important decision-making. LOCCATE is designed to facilitate this information for MDTs and provides a comprehensive record of the findings from standardised assessment in one recognised measure.

Overview of LOCCATE

LOCCATE was designed as a calibration tool and includes a set of criteria designed to operationally define levels of consciousness in the individual with a PDOC. These criteria are arranged to describe key behaviours seen in the individual with a PDOC, embracing the spectrum of diagnoses from Coma, VS, MCS−, MCS+ to MCS Emergent for both motor function and functional communication responses. There are 8 LOCCATE criteria, ranging from criterion 1 (no response for Coma) to criterion 8 (MCS Emergent). Using the results of any standardised PDOC assessment, LOCCATE requires the assessor to identify both:

- the individual's highest criterion and then
- the highest reproducibility within that criterion of responses (from 3 options)

to produce a 27-point LOCCATE calibration score (LCS) for both motor function and functional communication responses. To support the need for detailed clinical analysis of the wide range of responses within PDOCs, the LCS can also be used to position the individual in the Lower, Mid or Upper spectrum of each diagnostic category, depending on the complexity of responses observed.

LOCCATE scores the results of any PDOC assessment and involves four key stages:

1. Criterion scoring and the associated inferred diagnosis
2. Ranking reproducibility
3. Allocating a calibration score
4. Generating a LOCCATE criterion and value

Stage 1: Criterion scoring and the associated inferred diagnosis.

For the purposes of LOCCATE, the diagnosis is referred to as 'LOCCATE criterion and inferred diagnosis' and is based on the findings of the specific PDOC SNBAT. The eight LOCCATE criteria have been designed to categorise the responses of the individual with a PDOC for both motor function and functional communication. The relationship of the criterion to the inferred diagnosis is illustrated in Table 1.

Table 1. LOCCATE criterion and inferred LOCCATE diagnosis

Inferred LOCCATE diagnosis	Spectrum	LOCCATE criteria
MCS Emergent		8
MCS+	Upper	7
	Mid	6
	Lower	5
MCS−		4
VS (eyes open)	Upper	3 VS
	Mid	2 VS
	Lower	1 VS
Coma (eyes closed)	Upper	3 Coma
	Mid	2 Coma
	Lower	1 Coma

MCS, minimally conscious state; VS, vegetative state.

The eight LOCCATE criteria descriptors differ slightly for motor function and functional communication. While most of the behaviours observed in PDOC are described in each criterion, it is not possible to describe every single behavioural response seen in each category. Therefore, the assessor must use their clinical judgement to allocate the highest responses observed to the nearest possible LOCCATE criterion and this should be discussed with the MDT and/or the expert PDOC physician or treating physician to ensure responses are reliably interpreted. These eight criteria and related inferred diagnosis are illustrated in Table 2.

Table 2. LOCCATE criterion and inferred diagnosis

LOCCATE criterion	Inferred diagnosis	Criteria	Motor function/functional motor	Functional communication
8	**MCS Emergent**	Meets the RCP guidelines for emergence from MCS by demonstrating the required number of correct responses with one or more of the following: choice-making/matched pairs/functional use of an object or answering biographical or situational questions on two consecutive occasions.	**Motor function** Choice-making/matches and meets the RCP criteria for emergence. **Functional Motor** Uses functional objects, for example, a pen, meeting the RCP criteria.	Uses gesture or other methods of output (see output options) to make needs known. Makes choices or indicates "Yes/No" (see output options). Answers questions to situational and/or autobiographical questions, meeting the RCP criteria.
7	**MCS+ Upper**	Demonstrates one of the following: choice-making/matched pairs/functional use of an object. Demonstrates "Yes/No" but does not meet the RCP criteria. (Asking the client to ...)	**Motor function** Choice-making/matches but does not meet RCP criteria for emergence. **Functional Motor** Use of object, for example, a pen, but does not meet the RCP criteria.	Uses gestures or other methods of output (see output options) to make needs known. Makes choices or indicates "Yes/No" (see output options). Answers questions to situational and/or autobiographical questions but does not meet the RCP criteria.
6	**MCS+ Mid**	Follows visual, verbal instruction, tactile cues or discriminates. (Telling the client to …)	Follows instruction/cue or discriminates.	Demonstrates "Yes" and/or "No" but cannot functionally answer questions when asked.
5	**MCS+ Lower**	Responds appropriately directly to the type of stimulus, interacting with stimuli, not to verbal, written instruction or cues.	**Motor function** Cause-and-effect, copying. Presses the auditory feedback switch/iPad but does not follow direct instruction. **Functional motor** Completes simple functional tasks without instruction, for example, removes sock, adjusts hat, removes glasses but not to instruction.	Copies facial expression, gestures, words **OR** uses automatic speech to finish phrase **OR** verbally responds appropriately to stimuli, for example, "Go away" in response to having an injection.
4	**MCS–**	Localises to stimuli or meaningful spontaneous responses. **OR** Communicative responses to specific stimuli but not to instruction/cue/prompt.	**Motor function** • Localises, visual fixation, pursuit; • Body part towards stimulus; • For example, meaningfully and spontaneously brushes hair out of eyes (often repetitive). **Functional motor** • Active movement within guided activity felt with facilitation; • Unable to complete any aspect of task; • Unable to initiate task; • Manipulates form.	Communicative facial expression or meaningful vocalisation in context or to specific technique or stimuli. Intelligible verbalisation. Lacks meaning or not in context.
3	**Coma or VS**	Reflexive withdrawal responses to stimuli. **OR** Non-meaningful spontaneous responses.	Withdrawal. **OR** Non-meaningful spontaneous responses.	Reflexive non-meaningful facial expression, non-meaningful vocalisation to stimuli, and so on.
2		Reflexive.	Reflexive.	Reflexive non-meaningful facial expression.
1		No response.	No response.	No response.

MCS, minimally conscious state; RCP, Royal College of Physicians; VS, vegetative state.

LOCCATE criteria 1–3: Coma or VS

Both Coma and VS are classified along LOCCATE criteria 1–3. An individual in a coma is differentiated from an individual in a VS since the former shows no evidence of eye opening, no localisation to noxious stimuli and no understandable responses to external stimuli (Plum & Posner, 1982). Any reasons for eye closure that are not a result of the individual being unconscious are fully explored by the expert PDOC physician and their team.

The LOCCATE criterion can then be applied accordingly as being either Coma or VS for LOCCATE criteria 1–3 for the Lower, Mid and Upper spectra according to the type of responses observed; in the Coma diagnostic category, these relate to the levels from the Glasgow Coma Scale (GCS).

LOCCATE criterion 4: MCS–

Bruno et al. (2012) recommended subcategorising the individual's MCS diagnosis into plus (MCS+) and minus (MCS−) based on the grade of complexity of the observed responses. MCS− refers to individuals who show some evidence of localising responses, such as following an object with their eyes or targeted purposeful movement, such as scratching. The most basic meaningful functional communication response in MCS− recorded in the reviewed range of PDOC assessments is a meaningful facial expression to a specific stimulus or within context. Such localising motor function responses and functional communication facial expressions would be categorised at LOCCATE criterion 4.

LOCCATE criteria 5–7

MCS+ refers to individuals who demonstrate more complex behaviours, such as gestures, verbal command following, 'Yes/No' responses and so on. Since a wide spectrum of responses is seen in MCS+, this category has been subdivided in LOCCATE into Lower, Mid and Upper spectra. Table 2 illustrates the range and complexity of responses seen in individuals in MCS+.

To illustrate how responses are allocated to each criterion, LOCCATE criterion 5 (MCS+ Lower) motor responses would include cause-and-effect and copying, and for functional communication, copying with a gesture and/or copying a communicative facial expression.

LOCCATE criterion 6 (MCS+ Mid) motor responses would include an ability to follow verbal or written instructions or, for the functional communication modality, demonstrating a 'Yes/No' response but being unable to answer questions when asked.

LOCCATE criterion 7 (MCS+ Upper), motor responses would be allocated to an individual's ability to demonstrate choice-making, match pairs or demonstrate functional use of objects. For functional communication, there will be evidence of an ability to answer questions while not meeting the requirements of the RCP guidelines 2020. This subdivision is useful in providing a clearer commentary on the trajectory of change over time for the individual with an MCS diagnosis.

LOCCATE criterion 8: MCS Emergent

Emergence from MCS+ is characterised by reliable and consistent functional interactive communication, through verbalisation, 'Yes/No' responses or functional use of objects (Giacino et al., 2002). The RCP guidelines (RCP, 2013, 2020) further defined the parameters for the reliability and consistency of responses and broadened the functional options by adding the ability to demonstrate choice-making, matching pairs, or answering autobiographical or situational 'Yes/No' questions to facilitate consistent reporting within teams and across services.

When the series of each selected SNBAT PDOC assessment has been completed, the assessor should first identify the highest (best) LOCCATE criterion for both motor function and functional communication reproducible responses for each tool used.

Example

A WHIM assessment was conducted with Tim (a person living with a PDOC) in 8 sessions over a 10-day period. Tim was observed to follow the verbal instruction "move your left thumb" scoring 15 on the WHIM ("performs physical movement on verbal request"). This was his highest score on a motor function category. This produced a LOCCATE criterion 6 with an inferred diagnosis of MCS+ Mid for motor function.

Tim was also observed to smile to humour and scored 43 on the WHIM for "Smiles". This was his highest score on a functional communication category. This produced a LOCCATE criterion 4 and inferred diagnosis of MCS− for functional communication.

Stage 2: Ranking reproducibility of responses

A range of PDOC assessments can be applied at different frequencies depending on the framework or processes that apply. SMART is conducted 10 times over a 3-week period. The authors of the CRS-R recommend a minimum of 5 assessments over a 2-week period (Cortese et al., 2015; Wannez et al., 2017). For assessments such as the WHIM, which requires repeated assessment over time, it is also important to record how many sessions have been conducted to reach the LOCCATE criterion and the reproducibility and durability of responses, to help identify the patterns of responses observed within a given time frame.

The assessor therefore defines the reproducibility of the responses for the selected highest criterion for both motor and functional communication responses for each tool used by adding the number of times the response was observed in addition to the LOCCATE criterion achieved. The descriptors of reproducibility of responses are described in Table 3.

Table 3. Descriptors of reproducibility of responses for LOCCATE

Code	Reproducibility	Reproducibility of responses to same stimulus/instruction over ten sessions (or as relevant)
A	Seldom but reproducible	Occurs 2–4 sessions only[a]
B	Often	Occurs in five sessions or more but not consecutively
C	Always	Occurs in at least five sessions consecutively

[a]Needs to be reproducible over two or more different sessions to contribute to diagnostic category.

The reproducibility of the responses needs to be based on the responses to the same stimuli or type of response. For example, the frequency of tracking of a mirror (regardless of direction) should not be added to the frequency of tracking of a photograph. Likewise, LOCCATE will require, for example, the frequency of responses of facial expression, such as a smile, to be recorded but it is not to be added to the frequency of grimaces, since they are all stand-alone responses. The same applies to the recording of the frequency of responses to the same verbal or written instruction, question, matching objects, etc. This is an important feature because, by being very specific about the type and frequency of responses seen to a specific stimulus, it will help the assessor to more accurately establish the optimal conditions for higher frequency responses to specific stimuli or type of

responses and enable intervention strategies to be more focused and implemented accordingly. For example, if a patient smiles more frequently to a specific familiar photograph or familiar sound, or to a specific verbal instruction, then the team can focus their future intervention on those specific findings to try to enhance frequency of type of responses seen.

Descriptors of reproducibility of responses for LOCCATE

LOCCATE criterion 1 (VS or Coma Lower) and 8 (MCS Emergent) do not have different levels of reproducibility for each response for either motor function or functional communication. This is because a 'no response' at criterion 1 VS or Coma Lower cannot be reproduced. In terms of emergence from MCS, the patient is either meeting the national guidelines for emergence from MCS or they are not. LOCCATE criterion classification starts with 1 Coma Lower; then, in order, the criteria and reproducibility are 2A Coma Mid, 2B Coma Mid, 2C Coma Mid, 3A Coma Upper, 3B Coma Upper, 3C Coma Upper and then the same criterion and reproducibility for VS Lower, Mid and Upper. For MCS−, it is 4A, 4B, 4C then 5A MCS Lower, 5B MCS Lower, 5C MCS Lower, and so on. The highest response is LOCCATE criterion 8 for MCS Emergent.

Example

For the WHIM assessment example, a criterion 6A MCS+ Mid for motor function where the patient Tim followed the verbal instruction to "move your left thumb" 3 times over 8 sessions, and a LOCCATE criterion 4C with a smile to humour 6 times over 8 sessions, an inferred diagnosis of MCS− for functional communication would be recorded.

Stage 3: Allocation of the LOCCATE Calibration Score (LCS)

Each of the LOCCATE criteria and reproducibility options can be allocated an LCS from 1 to 27 as illustrated in Table 4.

Table 4. The LOCCATE criterion score

LOCCATE inferred diagnosis	Inferred diagnostic spectrum	LOCCATE criterion and reproducibility	LOCCATE criterion score
MCS Emergent		8	27
MCS	MCS + Upper	7C	26
		7B	25
		7A	24
	MCS + Mid	6C	23
		6B	22
		6A	21
	MCS + Lower	5C	20
		5B	19
		5A	18
	MCS−	4C	17
		4B	16
		4A	15
VS	VS Upper	3C	14
		3B	13
		3A	12
	VS Mid	2C	11
		2B	10
		2A	9
	VS Lower	1 VS	8
Coma	Coma Upper	3C	7
		3B	6
		3A	5
	Coma Mid	2C	4
		2B	3
		2A	2
	Coma Lower	1 Coma	1

MCS, minimally conscious state; VS, vegetative state.

Therefore, for a Coma diagnosis the LCS range is from 1 to 7, VS from LCS 8 to 14, MCS− from LCS 15 to 17, MCS+ from LCS 18 to 26, and MCS Emergent is designated LCS 27. If no motor function or functional communication responses are seen in the PDOC assessment, then the assessor will record LOCCATE criterion 1 as applicable to either VS or Coma and allocate LCS 1 for 1Coma, or LCS 8 for 1VS.

Example

In the example, the WHIM assessment produced a LOCCATE criterion and inferred diagnosis of 6A MCS+ Mid with an LCS of 21 for the motor function responses. For functional communication, a LOCCATE criterion and inferred diagnosis of 4C MCS− was produced with an LCS of 17.

Stage 4: Generating a LOCCATE criterion and value

Some SNBATs require mandatory training and accreditation while others do not. Therefore, to ensure objectivity, it is recommended that an expert PDOC assessor, as defined in the RCP guidelines (RCP, 2020) takes responsibility for signing off the agreed findings of the assessment(s) for LOCCATE, even when not conducting the assessment themselves. To provide an accurate agreed overview and expert interpretation of the results, LOCCATE should not be used to compare standardised assessment scores by those not qualified to use such assessments, for example, the WHIM being applied by non-professionals.

A LOCCATE value can be created in written form by presenting the motor value first followed by the functional communication value but separated by a colon.

Example

In the example for the WHIM assessment this would be presented as 21:17. The highest value overall is 21 and the LOCCATE inferred diagnoses are MCS+ Mid overall.

LOCCATE as a Clinical, Research and Audit Tool

There are two key applications for using LOCCATE as a calibration tool. These are LOCCATE variance and LOCCATE progression.

LOCCATE Progression

The **LOCCATE progression** provides a measure to show any change observed from SNBATs conducted over time with an upward, downward or level trajectory. The differences over time will illustrate the **LOCCATE Progression.** The recording of this data over time will help the expert PDOC physician and MDT to identify any potential causes for this trajectory. Any changes in the LOCCATE Progression in a downward trajectory might for example indicate an underlying medical problem or external factor which may be affecting the patient's ability to respond. Any changes in an upward trajectory need to be explored further to identify possible causes such as the provision of a new seating system for example, which may have affected the patient's ability to respond during the assessment.

LOCCATE Variance

LOCCATE can be used as a measure to help to define the variance of LCS (obtained from the results of the different SNBATs). For example, a higher LCS achieved from different SNBATs applied at the same time will provide the assessors with more detailed analysis, such as the use of a particular stimuli or verbal instruction in one SNBAT that is not mandatory in another SNBAT. This will provide quantifiable comparison data giving a clearer direction for MDT intervention and opportunity to explore these observed differences in responses more carefully.

LOCCATE as an Audit Tool

The multi-disciplinary team may also elect to use LOCCATE as an audit tool. This could be used to record not only the highest LOCCATE criterion, frequency, and inferred diagnosis, but to record all responses seen for each patient for each assessment used which can contribute to assessment, goal setting and intervention audits within the MDT. This information will enable the assessor to identify a range of information as required in the audit, including:

Patient:

- Accurate and relevant goals and intervention in relation to highest responses.
- Frequency of responses for each inferred LOCCATE diagnosis and LCS.
- Types of responses observed by professionals and SNBAT tools over whole cohort of patients in audit.
- First observed responses demonstrating evidence of awareness to identify the patterns over the sensory modalities and motor function and functional communication responses.

PDOC Assessment Tools:

- Features of assessment tools which identified initial evidence of awareness and or emergence from MCS.
- Comparison of sensitivity of different assessment tools for identifying different diagnoses and spectrum within each diagnosis.

MDT:

- To assess efficacy of interventions by monitoring trajectory.

Case Study

The clinical application of LOCCATE can be demonstrated using a case study example. The results of the PDOC assessments are illustrated in Table 5.

Table 5. LOCCATE summary of results for the case study

PDOC assessment								LOCCATE		
No	**Assessment tool**	**Number of assessments**	**Assessor initials**	**Assessment date range**	**Overall PDOC assessment score and diagnosis**	**M/FC**	**Highest responses/frequency description**	**LOCCATE criterion and reproducibility**	**LCS and LOCCATE value LCS for M and FC**	**Overall highest calibration score LCS/inferred diagnosis**
1	GCS	3	JB	1–10 March	GCS 3 Coma	**M**	No motor responses or eye opening × 3	1 Coma Lower	1:	1 Coma Lower
						FC	No functional communicative responses × 3	1 Coma Lower	1	
2	GCS	4	JB	10–15 March	GCS 8 Coma	**M**	Eye opening to pain × 2, abnormal reflexes × 3	2A Coma Mid	2:	2 Coma Mid
						FC	Incomprehensible sounds × 2	2A Coma Mid	2	
3	CRS	6	SR	1–12 April	CRS 8 VS	**M**	Flexor withdrawal × 4	3A VS Upper	12:	12 VS Upper
						FC	No FC responses observed	1 VS Lower	8	
4	WHIM	10	BC	1–10 April	WHIM 7	**M**	Grinding teeth × 6	2B VS Mid	10:	10 VS Mid
						FC	No FC responses observed	1 VS Lower	8	
5	WHIM	10	BC	12–20 April	WHIM 21	**M**	Visually tracks × 10	4C MCS−	17:	17 MCS−
						FC	Meaningful crying × 2	4A MCS−	15	
6	WHIM	10	BC	1–10 May	WHIM 14	**M**	No motor responses	1 VS Lower	8:	9 VS Mid
						FC	Mechanical vocalisations × 3	2A VS Mid	9	
7	SMART	10	DB	10–20 May	SMART MCS HI Mid (14)	**M**	Following verbal instruction to move hand, move head and lift thumb × 5	6B MCS+ Mid	22:	22 MCS+ Mid
						FC	Facial expression of smile and crying × 4	4A MCS−	15	
8	WHIM	10	AN	10–20 May	WHIM 43	**M**	Following verbal instruction to move head × 3	6A MCS+ Mid	21:	21 MCS+ Mid
						FC	Smiles to family × 9	4C MCS−	17	

CRS, Coma Recovery Scale; FC, functional communication; GCS, Glasgow Coma Scale; HI, highest inconsistent; LCS, LOCCATE calibration score; M, motor function; MCS, minimally conscious state; SMART, Sensory Modality Assessment and Rehabilitation Technique; VS, vegetative state; WHIM, Wessex Head Injury Matrix.

Table 5 illustrates a case study where the patient had a series of 8 different assessments over time. The case study is an example of an individual who was admitted to a neurological unit with a GCS score of 3 at the scene of an accident. This GCS score was derived from the recordings of no eye opening, no verbal response and no motor response. This would be the equivalent of LOCCATE 1 (Coma Lower, no response) for both motor function and functional communication responses. The LOCCATE value is 1:1 and the highest LCS overall on the 1–27 scale is 1.

During admission to the intensive therapy unit, a further series of 4 GCS assessments revealed a highest GCS score of 8, with eye opening to pain, abnormal reflexes, and incomprehensible sounds. This is associated with a LOCCATE criterion of 2A (Coma Mid), which is indicative of reflexive responses for both motor function and functional communication. This generated a value of 2:2 with a highest LCS of 2 overall. Therefore, a very slight change in the criterion and frequency of responses in the LOCCATE Coma inferred diagnosis was detected.

On admission to a rehabilitation unit, six CRS-R assessments were conducted, and the highest motor function response observed was 'flexor withdrawal'; no functional communication responses were observed. The overall highest CRS-R score was 8, indicating an inferred diagnosis of VS. The equivalent LOCCATE criterion was 3A (VS Upper) for motor function and 1 VS (VS Lower) for functional communication with a LOCCATE value of 12:8. The highest LCS was 12. Therefore, after assessment with the CRS-R, the inferred diagnosis changed from Coma Mid to VS in the upper spectrum demonstrating LOCCATE progression in an upward trajectory. This illustrates that LOCCATE can be used to reveal the complexity of responses and placement within a diagnostic spectrum of responses and within the range of inferred diagnoses when extracted from tools such as the CRS-R.

A series of 10 WHIMs conducted at the same time as the CRS-R identified a highest WHIM score of 7, with the highest motor function response of teeth grinding seen 6 times but not consecutively over the 10 sessions and no responses in the functional communication modality. This translates to a LOCCATE criterion of 2B (VS Mid) for motor function and 1 VS (VS Lower) for functional communication and a LOCCATE value of 10:8, with the highest LCS being 10. Despite both PDOC assessments producing the same diagnosis of VS, a

LOCCATE variance was observed with a very slightly higher LOCCATE value for motor function in the CRS-R (12:8) compared with the WHIM (10:8).

A follow-up series of 10 WHIMs provided a highest WHIM score of 21 recording the highest motor function response of visual tracking seen 10/10 times, and in the functional communication modality, a response of crying was seen 2/10 times. This translates to a LOCCATE criterion and inferred diagnosis of 4C MCS− for the motor function responses and 4A MCS− for functional communication, generating an LCS and value of 17:15. Therefore, this LOCCATE upward progression is demonstrated by a change from an inferred diagnosis of VS Mid to MCS− from the previous series of WHIM and CRS-R assessments.

Subsequently, the individual experienced chest infections and was admitted to an acute unit. On return to the rehabilitation unit, a series of ten WHIMs were conducted. No motor function responses aside from eye opening were recorded; in the functional communication modality, mechanical vocalisations were observed twice with a WHIM score of 14. This translates to an LCS of 1 VS (VS Lower) for motor function and 2A (VS Mid) for functional communication with a LOCCATE value of 8:9. Therefore, the highest LCS was (VS Mid) (9). Thus, since the previous series of PDOC assessments and according to the LOCCATE criteria, a downward LOCCATE progression was noted when the inferred diagnosis changed from MCS− to VS Mid and the LOCCATE value from 17 to 9.

Following this, a SMART Assessment and series of ten WHIMs were conducted concurrently. Both assessments revealed the same LOCCATE criterion and reproducibility of MCS+ Mid for motor function and MCS− for functional communication.

The results of this data can be analysed in a range of different dimensions in the LOCCATE database.

A LOCCATE variance was apparent when the LCS revealed that the value generated by SMART was 22:15, and 21:17 for the WHIM. A more careful analysis of the data reveals that in the SMART Assessment, a higher number of verbal instructions were followed, and their frequency was higher at 5/10 compared with the 1 verbal instruction observed in the WHIM. However, in the functional communication modality, a higher frequency (9/10) of smiles were observed in the WHIM assessment in a session with the assessor and family compared with the 4/10 seen in the SMART Formal Assessment. This more detailed

analysis and quantifiable comparison data provide a clearer direction for MDT intervention and opportunity to explore these observed differences in responses more carefully. For example, the MDT could explore following those verbal instructions seen in SMART in a range of settings to promote greater frequency and perhaps investigate the potential to explore the responses seen and link these motor function movements to 'Yes/No'. Additionally, the increased frequency of smiles with the client's family should be explored by the MDT to identify causative factors noted in the WHIM.

Careful analysis of the LOCCATE data can also identify any LOCCATE variances in the results of varying PDOC assessments. Also, a change in the LOCCATE progression seen in the trajectory as result of the impact of external factors, such as a chest infection, as seen in the WHIM assessment (assessment number 6, see Table 5) on the level and frequency of responses observed and the corresponding LOCCATE value can be identified. The differences between the results from different PDOC assessments can be explored further to identify any reasons for a higher level or higher frequency of reproducibility of response derived from these assessments. For example, for this case study, the expert PDOC assessor may explore why the WHIM and SMART LOCCATE values (assessment numbers 7 and 8) varied for both motor function and functional communication when conducted at the same time.

Completing the LOCCATE summary form, chart and graph

The results from the case study will be used to illustrate the process for completion of the three LOCCATE documents that the assessor can complete: summary form, trajectory chart and graph.

1. The LOCCATE summary form

The assessor will complete the LOCCATE summary form. An example of a completed LOCCATE summary form for the first two entries of the case study is illustrated in Figure 1 on the next page.

2. LOCCATE trajectory chart

The assessor can choose to complete the trajectory chart (Figure 2) to illustrate the results diagrammatically by entering all of the relevant assessment information as provided here for the case study, and the highest motor and functional communication LOCCATE criterion and reproducibility. The corresponding LOCCATE inferred diagnosis will be illustrated on the chart. This will provide an overview of the results and provide a trajectory over time.

3. LOCCATE graph

Additionally, the assessor can choose to complete the LOCCATE graph (Figure 3) by entering the LCS results as illustrated for the case study. This LOCCATE graph provides the results of the case study illustrating the trajectory over time.

4. LOCCATE flowchart

The LOCCATE flowchart (Figure 4) provides an overview of the LOCCATE process for easy reference.

Figure 1. Example LOCCATE summary form

LOCCATE Summary Form No:											
Standardised neurobehavioural assessment tools (SNBATs) results								LOCCATE			
No:	Assessment Tool	No of Assessments	Assessor Name/ Profession /Unit	Standardised neurobehavioural assessment tools (SNBATs) Date Range	SNBAT Score and Diagnosis (where applicable)	Motor/ FC	Highest Responses/ Frequency Description	LOCCATE Criterion, Reproducibility and Inferred Diagnosis	LOCCATE Calibration Score and Value LCS Per M and FC	Highest LCS	Overall Highest Criterion and reproducibility
1	GCS	3	Dr J Brown ITU	1-10 March	GCS 3 COMA	**M**	No motor Responses or eye-opening x 3	1 COMA Lower	1:	**1**	1 COMA Lower
						FC	No functional Communicative response x 3	1 COMA Lower	1		
2	GCS	4	Dr J Brown ITU	10 – 15 March	GCS 8 COMA	**M**	Eye opening to Pain x 2 Abnormal reflexes x3	2A COMA Mid	2:	**2**	2A COMA Mid
						FC	Incomprehensible Sounds	2A COMA Mid	2		
3	CRS	6	Sarah Ryan SLT	1-12 April	CRS 8 VS	**M**	Flexor Withdrawal x 4	3A VS Upper	12:	**12**	3A VS Upper
						FC	No Functional Communicative Responses	1 VS Lower	8		

Figure 2. Case study: LOCCATE trajectory chart

Assessment series number			1		2		3		4		5		6		7		8		
PDOC assessment			GCS		GCS		CRS		WHIM		WHIM		WHIM		SMART		WHIM		
LOCCATE inferred diagnosis	LOCCATE inferred diagnosis spectrum	LOCCATE criterion	M	FC	M	FC	M	FC	M	FC	M	FC	M	FC	M	FC	M	FC	LCS
MCS Emergent		8																	27
MCS	MCS+ Upper	7C Upper																	26
		7FI Upper																	25
		7HI Upper																	24
	MCS+ Mid	6C Mid																	23
		6FI Mid																	22
		6HI Mid																	21
	MCS+ Lower	5C Lower																	20
		5FI Lower																	19
		5HI Lower																	18
	MCS–	4C																	17
		4FI																	16
		4HI																	15
VS	VS Upper	3C																	14
		3FI																	13
		3HI																	12
	VS Mid	2C																	11
		2FI																	10
		2HI																	9
	VS Lower	1																	8
Coma	Coma Upper	3C																	7
		3FI																	6
		3HI																	5
	Mid	2C																	4
		2FI																	3
		2HI																	2
	Lower	1																	1

C, consistent; FI, frequent inconsistent; HI, highest inconsistent. CRS, Coma Recovery Scale; FC, functional communication; GCS, Glasgow Coma Scale; LCS, LOCCATE calibration score; M, motor function; MCS, minimally conscious state; PDOC, prolonged disorder of consciousness; SMART, Sensory Modality Assessment and Rehabilitation Technique; VS, vegetative state; WHIM, Wessex Head Injury Matrix.

Figure 3. LOCCATE graph: Calibration Scores per standardised neuro behavioural assessment tool

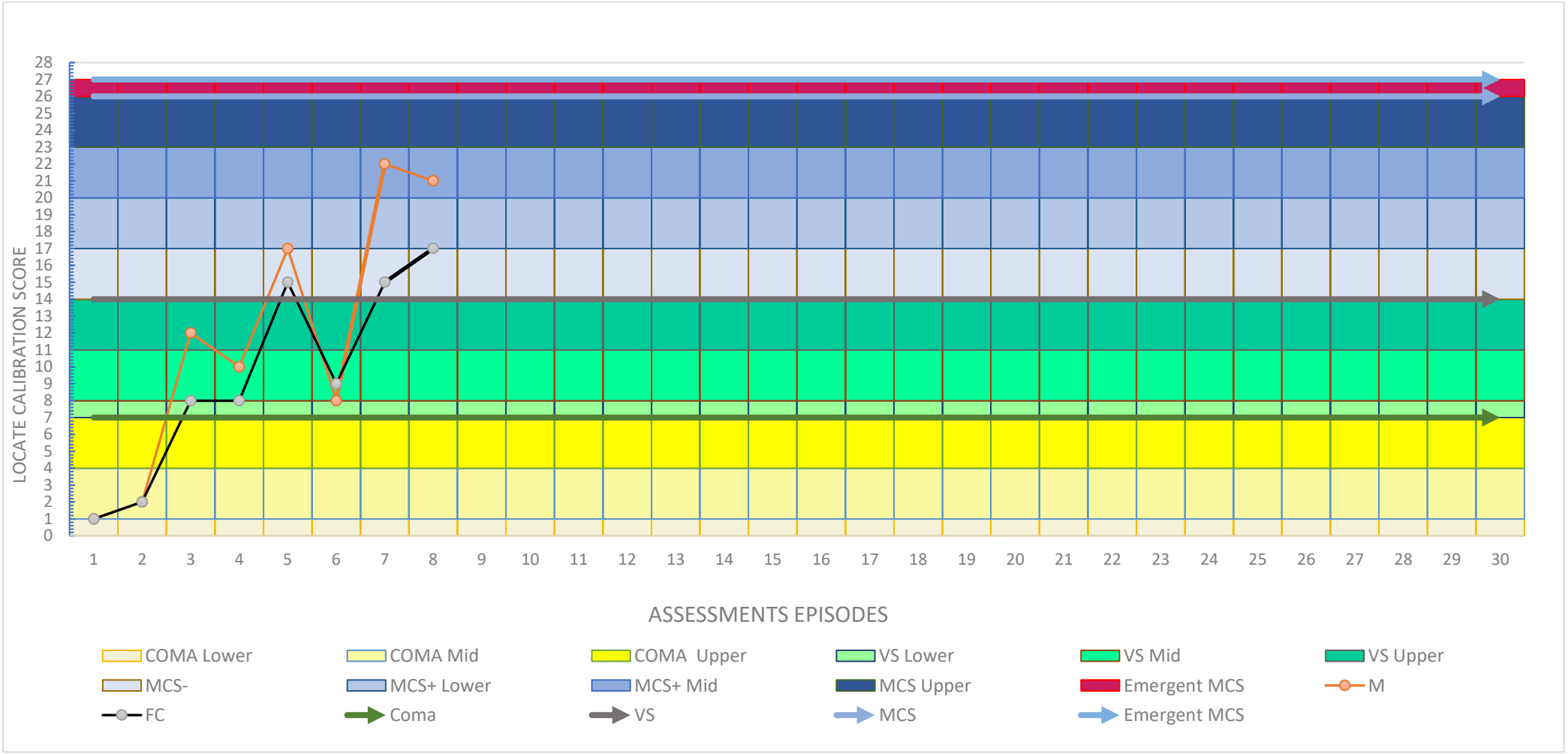


Figure 4. LOCCATE flowchart: Overview of the LOCCATE process

Stage 1: Criterion Scoring and associated Inferred Diagnosis

Use Table 2 to identfy the criterion and inferred diagnosis for highest motor and functional communicative response

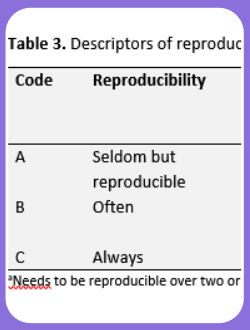


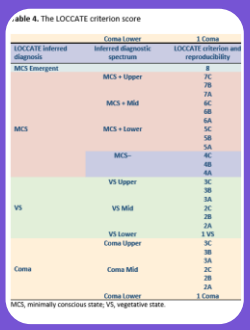
Table 3. Descriptors of reproduc

Code	Reproducibility
A	Seldom but reproducible
B	Often
C	Always

*Needs to be reproducible over two or

Stage 2: Rank Reproducibilty

Use Table 3 to identfy the reproducibility of response observed for both motor and functional communicatve response



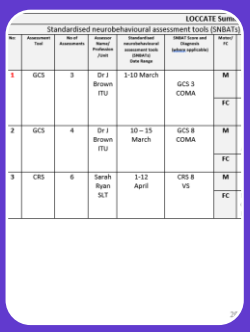
able 4. The LOCCATE criterion score

LOCCATE Inferred diagnosis	Inferred diagnostic spectrum	LOCCATE criterion and reproducibility
MCS Emergent		8
MCS	MCS + Upper	7C
		7B
		7A
	MCS + Mid	6C
		6B
		6A
	MCS + Lower	5C
		5B
		5A
	MCS–	4C
		4B
		4A
VS	VS Upper	3C
		3B
		3A
	VS Mid	2C
		2B
		2A
	VS Lower	1 VS
Coma	Coma Upper	3C
		3B
		3A
	Coma Mid	2C
		2B
		2A
	Coma Lower	1 Coma

MCS, minimally conscious state; VS, vegetative state.

Stage 3: Allocating a Calibration Score

Use Table 4 to identify the relevant LOCCATE calibration score for both the motor and functional communicative response



LOCCATE Sum

Standardised neurobehavioural assessment tools (SNBATs)

No	Assessment Tool	No of Assessments	Assessor Name/ Profession/ Zone	Standardised neurobehavioural assessment tools (SNBATs) Date Range	SNBAT Score and Diagnosis (delete applicable)	Motor/ FC
1	GCS	3	Dr J Brown ITU	1-10 March	GCS 3 COMA	M
						FC
2	GCS	4	Dr J Brown ITU	10 – 15 March	GCS 8 COMA	M
						FC
3	CRS	6	Sarah Ryan SLT	1-12 April	CRS 8 VS	M
						FC

Stage 4: Generating a LOCATE Criterion and Value

Use the LOCCATE Summary form to record the LOCATE Criterion both the motor and functional communicative response.

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Gill-Thwaites & Elliott Consultants

Specialists in Disorders of Consciousness

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For enquiries, please contact enquiries@gteconsultants.com

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