The Munich Coma Scale (MCS)

R. BRINKMANN¹, D. VON CRAMON, AND H. SCHULZ

From the Max-Planck-Institut für Psychiatrie, München, Germany

SYNOPSIS The level of coma can be measured by the assessment of changes of behaviour after different intensities of stimulation. Two additive scales (Guttman scales) for susceptibility to stimulation and reactivity were developed, constituting the Munich Coma Scale (MCS). The findings of previous investigations were repeated in a new sample of 67 comatose patients. Implications of the additivity of reactivity are discussed and related to the concept of 'behavioural arousal' advanced in the recent literature.

The states of severe disturbances of consciousness are often referred to as 'coma', although, strictly speaking, the word 'coma' refers to a state of complete loss of consciousness from which a patient cannot be aroused even by powerful stimulation.² Nevertheless, 'coma' has been widely used to indicate different gradations of disturbances of consciousness. In this article 'coma' is used in this rather general sense.

Among the different approaches towards a classification of coma (Regan and Browne-Mayers, 1956; Fischgold and Mathis, 1959; Jouvet, 1965; Marrubini, 1965; Paillas *et al.*, 1965; Bauer, 1966; Gulbrandsen *et al.*, 1972; Demedts and Pillen, 1973; Teasdale and Jennett, 1974) two types of classification may be distinguished. One approach is based on systematic neurological examination with the purpose of correlating neurological symptoms and the implicit morphological substrate with loss of consciousness (Fisher, 1969; Plum and Posner, 1972). The other approach is based on the fact that the loss of consciousness, the most important feature common to all comatose patients, is correlated with the behavioural aspects of the patients (Gulbrandsen *et al.*, 1972; v. Cramon *et al.*, 1975). In this instance, the depth of un-

responsiveness is determined by the assessment of behavioural responses to stimuli of different intensity. Both types of classification were combined into a single scheme by Jouvet (1965).

The following study is based on the latter approach to classification of comatose states. In a previous study four non-verbal, physical stimuli were selected out of an initial set of 10 stimuli, as these cover the whole spectrum of comatose patients quite satisfactorily and form an additive (Guttman) scale (v. Cramon *et al.*, 1975). A catalogue of some 59 stimulus-bound changes of behaviour at the outset of our experiments could be summarized into four types of reactions, which also form an additive scale.

It is the aim of this paper to repeat our experiments with a new sample, the hypothesis being that the reduced set of stimuli and the condensed form of subsequent reactions will give the same results as in the previous study. It is also hypothesized that the additive structure of the two scales is maintained.

METHODS

SUBJECTS Sixty seven patients with clinically presumed or diagnosed disturbance of attention were examined. Forty six of these were suffering from neurological diseases; 21 were intoxicated from self-poisoning in the course of suicide attempts. There were 30 male and 37 female patients. The median age was 52 years (range 17-18 years). The clinical diagnoses of the patients are shown in Table 1.

¹ Request for reprints should be sent to: Dr R. Brinkmann, Max-Planck Institut für Psychiatrie, Neurologische Poliklinik, Kracpelinstr. 10, D-8 München 40, BRD.

² *Dorland's Illustrated Medical Dictionary*, 25th edition. W. B. Saunders: Philadelphia & London, 1974.

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TABLE 1

CLINICAL DIAGNOSES OF 67 PATIENTS WITH
DISTURBANCES OF ATTENTION

<i>Clinical diagnoses of 67 comatose patients</i>	
Intoxications (suicide attempts with drugs)	21
Cerebrovascular diseases	12
Cerebral haemorrhage	6
Intracranial tumours	5
Vascular malformation	4
Arterial hypotension	4
Alveolar hypoxia	3
Sporadic encephalitis	3
Cranio-cerebral trauma	2
Subarachnoid haemorrhage	2
Strangulation	1
Brain abscess	1
Electrolyte imbalance	1
Delirium tremens	1
Wernicke's encephalopathy	1
Total	67

The above-mentioned scales will be referred to as the Munich Coma Scale (MCS). The MCS is made up of two scales: (1) the scale of susceptibility to stimulation and (2) the scale of reactivity.

SCALE OF SUSCEPTIBILITY TO STIMULATION The four non-verbal, physical stimuli are: one electrical (E), one tactile (T), one acoustic (A), and one optical (O). Further characteristics and modes of application are presented in Table 2. Stimuli are ordered according to their ability to arouse reactions, the order being, E>T>A>O.

TABLE 2

DESCRIPTION OF FOUR STIMULI

<i>Stimulus</i>	<i>Description</i>
Electrical (E)	Battery-operated device for electric shocks. Electrodes are attached to extensor side of 2nd and 3rd finger. (In cases of hemiplegia on unaffected side.) Electrodes cover 3 cm ² , intensity of current: ranges from 1–10 mA, minimum voltage: 600 volts, medium voltage: 1200 V; duration: maximally 5 s
Tactile (T)	Nylon hair: flexible. Diameter 0.05 mm. Application in the periocular, para-, and intranasal as well as in perioral regions on both sides for 30 s
Acoustic (A)	Siren: battery-operated device for production of siren sounds. Application: stimulation on both sides, distance to ear approximately 30 cm. Sound pressure: 90 dB, frequency range 300–1000 Hz. Duration 20 s
Optical (O)	Flashlight: light intensity: 6000 Lux at 10 cm distance. Duration: 10 flashes of 1 s on both sides

The scale has five steps, four of which correspond to the stimuli, the fifth being 'no response'. A step is reached when any one of the reactions described below occurs up to 30 seconds after the onset of stimulation.

SCALE OF REACTIVITY The four types of reactions are: (1) motor reactions, (2) mimic reactions, (3) orientating reactions, and (4) communicative reactions. Details are presented in Table 3. The types of reactions are ordered according to their appearance in the different stages of coma, the order being motor reactions before mimic reactions, mimic reactions before orientating reactions, orientating reactions before communicative reactions.

TABLE 3

DEFINITION OF FOUR TYPES OF REACTIONS

<i>Types of reactions</i>	<i>Definition</i>
Motor 1	Any movement of trunk, extremities, or head without clear-cut directional components in relation to stimulus or experimenter
Mimic 2	Frowning; any movement of perioral muscles, of tongue, or of muscles involved in act of swallowing; single or repeated contraction of eyelids with closed or open eyes
Orientating 3	According to direction and duration definite turning of head to or away from stimulus; opening of eyes or state of open eyes*
Communicative 4	According to direction and duration, definite looking at stimulus or experimenter; verbal utterance with evident semantic content in native language of patient

*Although the state of open eyes in itself is no reaction it had to be taken into account because it is supposed to represent that level of attention which is also critical for the physical opening of the eyes.

The scale has five steps, four of which correspond to the described types of reactions, the fifth being unresponsiveness. A step is reached when one of its constituting reactions has been observed up to 30 seconds after the onset of stimulation with any of the four stimuli.

PROCEDURE Examinations were carried out under bedside conditions. After an initial observation period of five minutes during which spontaneous changes of behaviour were recorded, the four stimuli were applied in random order. Time intervals between stimuli lasted for at least one minute. In cases of prolonged arousal after stimulation, time intervals are extended accordingly. Reactions are recorded by the experimenter after each stimulation. Observed changes of behaviour after stimulation are attached to one or more of the four types of reactions and documented on a special form (Fig. 1).

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MCS
(Munich Coma Scale)

Name: _____ Date of birth: _____

Ward : **Date:** **Time:** **Investigator:**

Diagnosis.

Medication:

Type of reactions Stimuli	I	II	III	IV	Notes
Sp					

Stimuli :

E = electrical

T = tactile

A = acoustic

0 = optical

Vary the sequence of stimuli

Sp = Type of reactions observed
in spontaneous behavior
(5 min. observation)

Types of reactions :

I body movements
(head, trunk, extremities)

- II frowning
- eyelid contractions (blinks)
- oral movements
- swallowing

- head movements towards or away
- eyes open with stimulation
- eyes open before stimulation

IV glance towards or away
verbal expression

FIG. 1 *Formula for the documentation of MCS recordings.*

RESULTS

SCALE OF SUSCEPTIBILITY TO STIMULATION The distribution of the susceptibility to stimulation of 67 patients is shown in Table 4.

TABLE 4

POSITION OF 67 PATIENTS ON FIVE-STEP SCALE OF SUSCEPTIBILITY TO STIMULATION

	Steps on scale of susceptibility to stimulation					
	0	1	2	3	4	
Number of patients	7	9	18	19	14	S=67

There were no exceptions to the additivity of this scale. An error would be a gap in the postulated hierarchy indicating that a reaction was elicited to a weaker stimulus but not to a stronger one.

SCALE OF REACTIVITY The distribution of the reactivity of 67 patients is shown in Table 5.

TABLE 5

POSITION OF 67 PATIENTS ON FIVE-STEP SCALE OF REACTIVITY

	Steps on scale of reactivity					
	0	1	2	3	4	
Number of patients	7	11	12	21	16	S=67

There were no errors on this scale. In this instance, an error would mean the lack of a type of reaction of a lower order—that is, a more frequently observed type—although a higher order type of reaction was elicited.

CORRELATION BETWEEN THE TWO SCALES The correlation between the two scales is shown in Fig. 2.

Scale of susceptibility to stimulation		0	1	2	3	4	Σ
Scale of reactivity	0	7					7
	1		6	5	0	0	11
	2		3	8	1	0	12
	3		0	5	13	3	21
	4		0	0	5	11	16
	Σ	7	9	18	19	14	67

FIG. 2 Distribution of 67 patients along the scale of susceptibility to stimulation and the scale of reactivity.

A high correlation ($CP=0.82$; Lienert, 1973) was found between the two scales. There were no cases with high susceptibility to stimulation—that is, reaction to weak stimuli—and low order reactivity, nor were there cases with low susceptibility to stimulation and high order reactivity. Errors are below 1% for both scales in this and in the previous investigation.

DISCUSSION

In repeating previous results (Brinkmann *et al.*, 1975; v. Cramon *et al.*, 1975; Schulz *et al.*, 1975) the MCS is assumed to be a reliable instrument for the classification of the level of coma. The main principle of the scale—that is, the exclusive observation of stimulus-bound changes of behaviour—has proved adequate for objective classification. It has already been shown (Brinkmann *et al.*, 1975) that the distribution on the MCS allows no differential diagnosis as to the aetiology of the comatose state. Consequently, coma due to space occupying lesions cannot be differentiated with this instrument from coma due to barbiturate overdose. Further restrictions have to be made for the application of the MCS in cases of slight coma. There are patients reaching the highest step on each scale who will nevertheless be regarded clinically as 'slightly somnolent'. In these cases verbal stimuli or tasks may prove to be more adequate (Jouvet, 1965; Teasdale and Jennett, 1974). Verbal material has so far been rejected for two reasons: (1) homogeneity of stimuli would be abandoned and (2) measurement of coma might be interfered with by language capabilities. The lengthening of our non-verbal scale would encounter the following difficulties: the stimuli would have to be well over sensory threshold to be distinguished from background noise and should arouse replicable changes of behaviour.

Errors on the scale of susceptibility to stimulation may result from incorrect observation or specific neurological deficits such as complete blindness, deafness, or anaesthesia. Incorrect observation can be ruled out by repetitive application of the MCS. When the 70 patients of the previous study (v. Cramon *et al.*, 1975) are added to the 67 patients of this study there were only two errors on the scale of susceptibility to stimulation in these 137 patients, which indi-

cates that on rare occasions specific neurological symptoms may interfere with the scaling procedure.

The scaling of the types of reactions is possible only if the frequency and the intensity of a type of reaction are neglected. An increase of reactivity always implies maintenance of already elicited reactions.

Use of the MCS enables the investigator to place every patient on the scale of susceptibility to stimulation and reactivity. Both scales are to some extent constructed independently: when measuring susceptibility to stimulation, reactions are recorded as yes-or-no; when measuring reactivity, no attention is paid to stimulus conditions under which the types of reactions occurred. Nonetheless, we have found a high correlation between the two scales which leads to the conclusion that the balance between external input (stimuli) and internally generated output (resultant changes of behaviour) is maintained throughout the continuous decrease of reactivity and susceptibility to stimulation in the different stages of the development of coma.

'Arousal' in the recent literature (Andrew, 1974; Posner and Boies, 1971; Pribram and McGuinness, 1975) is defined as a phasic physiological or behavioural response to sensory input. Making use of this definition we conclude that the MCS allows measurement of behavioural arousal in comatose states.

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