A bedside method to identify disturbances of cerebral function caused by illness of or trauma

The mental status examination

Thierry Ettlin[a], Udo Kischka[b]

[a] Reha Rheinfelden, Switzerland
[b] Oxford University Hospitals, United Kingdom

Summary

The mental status examination is an instrument of behavioural neurology that is used to identify and characterise specific disturbances of cerebral function relating to cognitive functions (such as memory and language), emotion and overt behaviour. It is conducted in a systematic fashion but is simple enough to be used at the bedside. Neurological conditions in which the mental status examination can provide clinically important information include stroke, encephalitis, dementia, hypoxic or metabolic encephalopathy, cerebral tumours and traumatic brain injury.

This chapter describes methods to assess the following brain functions: level of consciousness, attention, concentration and mental control, language, memory, constructional ability, higher level sensory and motor functions, frontal lobe (executive) functions, and neuropsychiatric control functions.

Key words: neurology; cognitive functions; behavioural neurology; cerebral dysfunction; trauma of the brain

The mental status examination

The mental status examination is used to identify and characterise specific disturbances of cerebral function, caused by illness or trauma of the brain. It is an extension of the standard neurological examination. While the latter focuses mainly on motor and sensory functions, the mental status examination collects valuable additional information relating to cognitive functions (such as memory and language), emotion, and overt behaviour. It is conducted in a systematic fashion but is simple enough to be used at the bedside. It is an instrument of a subspecialty called behavioural neurology. In our opinion, the mental status examination should be an integral part of a full neurological examination.

The mental status examination uses several *basic principles* to come to a conclusion about the person's mental state and, if abnormalities are found, to establish a valid hypothesis regarding the underlying cause of the abnormality:

- The examiner observes the patient's spontaneous behaviour and notes signs such as sleepiness, apathy, restlessness, pressure of speech, and exaggerated or diminished responsiveness to environmental events.
- Taking a history is crucial; ideally, the history should be taken not only from the patient, but also the partner or a relative who has known the patient for a while and may have observed behavioural changes. The onset (sudden or slow, triggered by external events or not) and course of the abnormalities (e.g., gradually worsening, or fluctuating) gives valuable information.
- The examiner assesses the patient's mental functions in a systematic fashion, using a collection of methods that have previously been shown to be specific for certain functions, such as attention, memory or language. The selection of specific methods of assessment may vary between different patients depending on the individual's general state.
- The examiner should form a hypothesis about the most likely biological cause of the mental abnormalities, such as encephalitis, stroke, Alzheimer's disease or substance abuse. In most cases, it should be possible to make an educated guess as to whether the patient has a diffuse disturbance of brain function or a focal cerebral lesion, and which parts of the brain are most likely affected.
- Alternative explanations for the mental abnormalities need to be considered that do not include a structural injury to the brain, such as schizophrenia, major depression, or a nonorganic "psychogenic" disorder.

In some cases, the mental status examination can be used to find indications that a cerebral dysfunction exists and can lead to further investigations such as magnetic resonance imaging (MRI) scans of the brain. In other cases, in which cerebral lesions are already known through previous investigations, it is still crucial to assess the way in which the patient is affected in his or her mental functions, to advise him or her on problems that may be expected in everyday life situations such as family life and work, and to plan his/her rehabilitation.

Neurological conditions in which the mental status examination can provide clinically important information include stroke, encephalitis, dementia, hypoxic or metabolic encephalopathy, cerebral tumours, and traumatic brain injury.

The mental status examination does not need to take a long time to administer. An experienced clinician can perform it in 15 to 30 minutes. If necessary, the patient can be referred for an extensive neuropsychological

Table 1: Glasgow coma scale.

Eye opening	Spontaneous	4
	To speech	3
	To pain	2
	Nil	1
Best verbal response	Orientated	5
	Confused conversation	4
	Inappropriate words	3
	Incomprehensible sounds	2
	Nil	1
Best motor response	Obeys commands	6
	Localises	5
	Withdraws	4
	Abnormal flexion (decorticate)	3
	Extends (decerebrate)	2
	Nil	1

assessment, which includes standardised psychological tests but takes several hours to complete.

Assessment of specific brain functions

The mental status examination is used to assess the following brain functions: level of consciousness, attention, concentration and mental control, language, memory, constructional ability, higher level sensory and motor functions, frontal lobe (executive) functions, and neuropsychiatric control functions.

The examiner needs to be aware of factors that may influence the patient's performance in the different functions. This information includes the patient's medical or neurological diagnosis, age, education, family history of hereditary illnesses, and current and former medication.

Level of consciousness

Traditionally, level of consciousness has been described in the following terms: alertness; somnolence (sleepiness), the patient appears tired but can be roused easily; sopor, the patient can hardly stay awake, and only for very brief periods when being arused by strong stimuli; coma, no response to stimuli but some reflexes are still preserved.

Over the recent decades, the Glasgow coma scale (GCS) has become the most widely accepted method for assessing a patient's level of consciousness. Depending on the patient's motor responses, verbal responses and eye opening, he or she is assigned a numeric value from 15 (normal consciousness) to 3 (deepest coma). Its major advantages are that the GCS is quick to administer, and that it allows for changes in a patient's level of consciousness to be picked up reliably (table 1).

Maintaining normal levels of consciousness depends on the intactness of the ARAS (ascending reticular activating system), which arises from the brain stem reticular formation and sends its axons diffusely to all cortical areas. Coma is usually caused either by damage to the brain stem, or by widespread damage to the whole brain.

Attention, concentration and mental control

Attention is a complex and multifactorial function that depends on alertness, vigilance and control of distractibility. Attention refers to a person's ability to attend to a stimulus or situation without being distracted by extraneous stimuli. Concentration is the ability to sustain attention over a period of time.

Attention should be assessed first because all other functions that are assessed in the mental status examination depend on intact attention.

Assessments of attention are: digit repetition; A-test; reversal of automated series.

All these tests are dependent on intact language functions. They cannot be used in patients with aphasia.

Digit repetition: This assesses a person's ability to focus their attention for a very brief time. The examiner recites random series of digits and gradually increases the number of digits; e.g.,

4-7-1-6

3-8-2-5-9

9-6-2-5-8-1

4-7-9-3-2-5-8

A normal performance is the ability to repeat 6±1 digits. Deficits in this test are found in patients with lesions in the reticular formation in the brain stem, as well as diencephalic and frontobasal regions.

The *A-test* examines concentration. The examiner recites a random series of letters over the course of one or two minutes and instructs the patient to give a sign every time the examiner says the letter A. Healthy people make no mistakes in this test, i.e., they do not miss the mention of a letter A.

Tests of *reversal of automated series* assess patients' mental control functions. The examiner instructs the patient to recite the months of the year or the days of the week backwards, or to spell words backwards. This examination tests the patient's ability to overcome the natural tendency to recite an overlearned series by asking him to reverse the order.

Another test of mental control is "serial sevens", whereby the patient is instructed to keep subtracting 7 from 100. However, this test depends not only on attention, but also on mental arithmetic and memory.

A good performance in digit repetition but poor performance in reversed order indicates a complex disturbance of frontal attention functions.

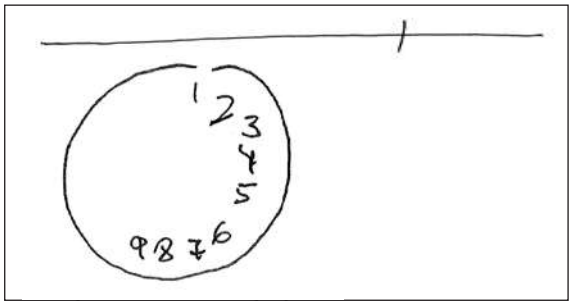

Figure 1: Left sided visual hemineglect.

Unilateral inattention or *hemineglect* is a condition that is mostly found in patients with injury to the right hemisphere. These patients cannot turn their attention to the left side of their body or the left side of the space around them. Hemineglect is often noticed by observation of the patients' spontaneous behaviour: they may eat only the food on the right side of the plate, shave only the right side of their face, and fail to notice people approaching them from their left side.

Hemineglect can be tested for within the visual modality by asking the patient to look at the examiner's nose and moving one's two hands simultaneously in both sides of the patient's visual fields. Similarly, sensory hemineglect is tested by touching both the patient's hands simultaneously.

Further tests of hemineglect are line bisection (the patient is shown a horizontal line on a piece of paper and is asked to cross it with a vertical line in its middle), or asking the patient to draw a clock face, a house, or a flower (fig. 1).

Language

The following language functions are assessed: spontaneous speech, comprehension, repetition, naming, reading, and writing.

In order to assess the patient's *spontaneous speech*, the examiner should ask open questions (e.g., "Tell me about your work") rather than questions that can be answered with "yes" or "no", or with a single word. In this way, the patient is encouraged to speak in his/her own words in full sentences. Many speech and language disorders can be diagnosed simply by listening to the patient talking.

Dysarthria (slurred speech) is a motor disorder of speech articulation, caused by a failure of coordination of the muscles that are engaged in producing speech sounds. These patients have no difficulty with understanding verbal information, word choice or grammar.

Patients with *aphasia* have difficulty processing verbal information. This difficulty can affect either the comprehension of spoken language, or the production of words and sentences, or both. The most common types of aphasia are called expressive aphasia and receptive aphasia.

Expressive aphasia (e.g., Broca's aphasia) is characterised by nonfluent, effortful speech. The patient struggles to find words and to combine them into sentences. The patients use mostly short and simple words and preferably nouns, and it takes them a long time to get across what they try to express. The patients have difficulty naming objects that are shown to them. An example of expressive aphasia would be "Car...car...car...aah... now...aaah...son...son..." by a patient who apparently tried to express that he was expecting a visit from his son. In extreme cases, patients' utterances are reduced to a single short word or syllable that they keep repeating, e.g., "un...un...un...". Patients with expressive aphasia are very aware of their language impairment and are often frustrated by it. In patients with pure Broca's aphasia, comprehension of spoken and written language can be well preserved. Writing, however, is usually also severely affected.

Naming can be tested by showing the patients objects or photos of objects and asking them to name them. The examiner should start with common words such as "nose" and then introduce less common words such as "lapel".

Receptive aphasia (e.g., Wernicke's aphasia) is in some ways the opposite of expressive aphasia. The speech is fluent and rapid, sometimes with pressure of speech. Patients often form long and sometimes grammatically correct sentences, but some words are formed incorrectly, called paraphasias. However, the patients' central problem during speaking is that their verbal production is devoid of meaning and seems random when listened to for a while. Verbal comprehension is disturbed, sometimes profoundly so. The patients are mostly unaware that their verbal output is meaningless.

Testing of verbal comprehension should start with simple instructions such as "point to the door" or the question "Is this a door?", which can be answered with a simple yes or no answer. The instructions should then be made gradually more difficult by adding two- step and three-step commands, e.g., "show me the door, then the window, then your nose". The examiner can also use passive constructions, e.g., "The lion was killed by the tiger. Which animal is now dead?"

Patients with *global aphasia* are nonfluent, but their comprehension is also seriously disturbed.

Conduction aphasia is a relatively rare condition in which comprehension and production of language are only mildly impaired, but repatition of spoken words and sentences is extraordinarily difficult for these patients.

Patients with expressive aphasia usually have lesions in the posterior part of the left frontal lobe, patients with receptive aphasia, in left posterior temporo-parietal areas. Conduction aphasia is typically found in patients with lesions around the Sylvian fissure.

Reading and the comprehension of written material can be tested by handing the patient a sheet with sentences that give instructions, such as "close your eyes" or "touch your left ear".

Writing can be tested by dictating words and sentences to the patient.

Alexia (difficulty with reading) and agraphia (difficulty with writing) suggest a lesion in posterior parts of the left hemisphere.

Memory

Several memory systems have been proposed by different authors, but the most widely used distinction is a simple one between short-term memory and long-term memory. Short-term memory has also ben called working memory and refers to our ability to keep information active in our mind for seconds up to a very few minutes. It is thought that we can keep 7±1 items in our working memory, and this information is rapidly replaced by new incoming information. The information will then either fade, or it will be laid down in long-term memory from where it can later be retrieved.

We can distinguish three processes of long-term memory: learning; storage; retrieval (recall).

These processes are handled by different parts of the brain. The working memory is processed in the prefrontal cortex, from where selected information is transported to the hippocampus, which keeps the information active over days and weeks. During this period, the hippocampus lays down the different aspects of the information in the cortical association areas where they are stored in the long term. This is organised in such a way that the visual aspects of an event are stored in the visual association cortex, the auditory elements are stored in the auditory association cortex, etc. When we recall information or an event, the prefrontal cortex retrieves it from the different association cortices and reassembles the different elements into a whole memory. Remembering is therefore an active, reconstructive process. This organisation of the memory systems explains the observation that a patient's remote memories, such as those of their parents or their school days, are often well preserved even when they are unable to remember what they had for breakfast. It would require widespread destruction of almost the whole cortex to erase all their older memories.

The *assessment* of a patient's memory needs to address the abovementioned diversity of learning and memory processes. It also needs to take into account the fact that learning and storage of verbal information occurs mainly in the left hemisphere, whereas non-verbal information is processed predominantly in the right hemisphere.

Testing a patient's *orientation* to person, time and place is useful to gain a quick and rough impression of their recent memory.

Working memory is often tested by reversing the digit repetition test described above under attention, but the patient now has to repeat the number sequences in reverse order.

The ability to *learn new verbal information* is mostly assessed by using lists of words that are recited by the examiner and have to be repeated by the patient (immediate recall). This process is repeated several times. Most healthy people are able to learn eight words within four practice trials.

The patient's ability to lay down longer lasting memories is tested by continuing with different neurobehavioural tasks, and later asking the patient to reproduce the earlier word list or story (free recall). If the patient is unable to do so, the examiner can give cues (e.g., if the patient does not remember "apple", the examiner can say "it was a fruit" or "it started with an A". By comparing the performances on free recall and cued recall, one can determine whether the patient has difficulty with storage (in which case cuing would not help) or with retrieval (in which case it would help). Healthy people can usually recall six to eight words out of a list of eight words after 15 minutes.

Memory for nonverbal material can be tested by presenting figure drawings. Ideally, these figures should be as abstract as possible, making it impossible for the patient to give them matching names such as "house" or "sun".

Deficits in learning new information are common in patients with damage to the temporal lobes (which contain the hippocampus), such as traumatic brain injury, herpes simplex encephalitis and Alzheimer's disease. Patients with frontal lobe lesions typically benefit from cues, indicating that their storage is relatively good but their retrieval is impaired. If a patient reports that they cannot remember their parents or their school days while their recent memory is well preserved, then the possibility of a psychogenic condition should be considered.

Constructional ability

The ability to produce or reproduce drawings of two-dimensional figures or three-dimensional objects requires the ability to perceive and imagine these objects and to produce a drawing that resembles them. It is a complex process that involves the integration of occipital, parietal, temporal and frontal functions and is therefore often disrupted even after relatively mild brain damage when other cognitive functions are not impaired.

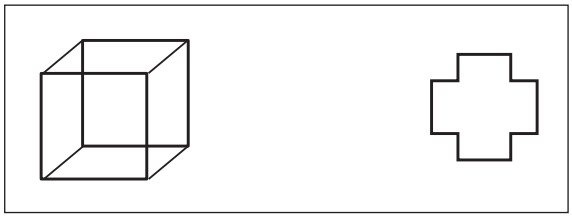

Figure 2: Testing for constructional ability.

These functions are tested by showing the patient drawings of two- or three-dimensional objects and asking them to copy them. Furthermore, the patient can be asked to draw a clock face, a flower or a house (fig. 2).

Higher level sensory and motor functions

The brain is organised in a hierarchical fashion. This is true for sensory, motor and cognitive functions.

Incoming sensory information is first processed in the primary cortex according to simple physical attributes (e.g., the primary visual cortex distinguishes different colours and orientations of lines), and is then processed further in ascending complexity within secondary and tertiary association areas. Finally, constellations of certain lines, spots and angles are categorised into recognisable concepts (e.g., a chair, an animal, or a face).

Visual agnosia is the inability to recognise objects although the patient has normal visual acuity and full visual fields. It is tested by showing the patient an object or a drawing of an object and asking them to name it. If the patient is aphasic, then he or she can be asked to show what is usually done with it (e.g., a hammer). If a patient is unable to name an object and describe its use when looking at it, one can let the patient touch the object. If he/she is then able to name it and describe its use, one can conclude that the patient has a disorder of the visual system. Special forms of visual agnosia are colour agnosia and prosopagnosia (the inability to recognise faces). They can be tested by showing colours and famous faces and asking the patient to name them. Visual agnosia is typically found in patients with damage to higher visual association areas in temporo-occipital regions.

Performing a voluntary movement is the result of a hierarchical process that starts with a mental plan of the movement in the premotor cortex, which activates the required motor fields within the motor cortex, and this in turn sends signals through the pyramidal tract and the peripheral nerves to the muscles that are then contracted and relaxed in a certain sequence.

Apraxia refers to a patient's difficulty to perform complex movements or sequences of movements even though he/she has no muscle weakness and no problem with coordination (no ataxia). The basic difficulty of a patient with apraxia is a defect in motor planning. In some patients, apraxia is apparent when watching them perform everyday activities such as dressing themselves. The common ways to test a patient for apraxia is to ask them to perform movements (e.g., "show me how you brush your teeth, how you comb your hair, how you blow out a match"), and to ask them to copy movements that are performed by the examiner.

Executive and frontal functions

The executive functions that are controlled by the frontal lobes of the brain are complex and include our ability to initiate goal-directed activities, to plan our actions ahead, to react flexibly and creatively in new situations, to appropriately suppress our impulses including aggressive urges, to reflect upon our actions and on the effect they have on other people, and to perceive social cues and respond to them in an appropriate fashion.

Patients with executive dysfunction often show some of the following behaviours:

- disinhibition – showing inappropriate social behaviour;
- irritability, lack of patience and possibly aggression;
- impulsivity and lack of regard for the consequences of their actions;
- impaired ability to organise and plan ahead;
- reduced insight – many patients with frontal lobe injury do not realise the full extent of their deficits;
- egocentricity – in conversation, these patients tend to insist on their own point of view and fail to take another person's opinion into account;
- inflexibility in thinking – some patients with frontal lobe injury can perform reasonably well in routine activities, but fail when encountering a new situation that requires flexible and creative thinking;
- perseverations – patients may be repetitive and get stuck on one topic they keep talking about;
- reduced initiative (apathy) – some patients with frontal lobe injury show reduced initiative to start goal-directed activities.

Some of the patient's cognitive and behavioural difficulties listed above are best explored simply by asking the patient and a family member whether the patient displays any of these difficulties and abnormalities, and whether they have recently worsened. Often there is a discrepancy between the patient's account, who denies these difficulties, and the family member who states that the patient does indeed have them (e.g., irritability and anger outbursts).

The examiner should also listen to the patient's spontaneous speech and narrative discourse to determine whether there are signs of reduced verbal production,

Figure 3: Alternating pattern.

fixation on details, lack of distance, discursive discourse, missing chronology, or perseverations (repetitions).

For the assessment of the executive functions, the following tests can be used.

Motor control and programming

Suppression of reflexes and motor impulses:

Go – no go: The examiner instructs the patient: "Tap twice, when I tap once; but when I tap twice, don't tap at all." A typical error of patients with frontal dysfunction is the inability to stop the impulse to tap after the examiner tapped twice.

Programming and performance of series of movements

Rhythm tapping: The subject is asked to repeat two different rhythms tapped by the examiner:

(-..-..-..) (--...--...--...-)

Patients with frontal lesions have trouble repeating the second, complex pattern that requires constant switches in rhythm.

Luria's hand sequences: Two steps: in this easier version, the examiner makes a fist, then extends his fingers, holding his hand horizontally. The subject has to repeat this alternating movement 10 times. Three steps: A third movement is added, the examiner turning his hand by 90° with the extended fingers still pointing forward. Number of trials necessary to learn the sequence, fluency and perseverations are rated.

Alternating pattern: The subject is told to copy a drawing without lifting the hand from the paper. The test requires alternating between peaks and blocks; a typical error ascribed to frontal lobe dysfunction is to draw two peaks in a row.

These tests are difficult for patients with lesions in the premotor cortex of the frontal lobes (fig. 3).

The following tests examine some of the functions of the prefrontal cortex.

Mental control

Resistance to interference, e.g., the ability to reverse automated series

Serial sevens: The subject is instructed to count backwards by seven starting from one hundred (100-93-86 ... all the way down to 2). Typical errors of patients with frontal lobe lesions are stereotypes (e.g., 100-93-83-73 ...) or the switch to multiples of seven as learned at school (e.g., 79-70-63-56 ...).

Reverse spelling: We recommend using "earth" which contains pairs of letters (ea, th) that commonly occur in this order. They are expected to elicit a stereotype when trying to spell them backwards (e.g., t-h-r-e-a).

Weekdays in reverse, Months in reverse: Typical errors of patients with executive dysfunction due to frontal lobe injury are to fall back into overlearned patterns, e.g., "December, November, October, September, August, September".

Fluency

Verbal fluency is usually tested by asking the patient to name as many words of a certain category (e.g., animals) as possible within one minute. Another test is the FAS test whereby the patient is asked to produce as many words as possible beginning with the letter F within one minute, then the letter A, then the letter S. Healthy people are usually able to name 20 to 25 animals, and slightly fewer numbers of words beginning with FAS.

Abstract thinking

The examiner names two objects and asks the patient which category they both belong to. For instance, "apple" and "orange" are both fruit. Another test is to ask the patient to explain the meaning of proverbs, e.g., "Rome was not built in a day".

As mentioned at the beginning of this article, the observations made during the mental status examination should provide the examiner with sufficient information to make a differential diagnosis of probable underlying causes for the patient's difficulties. If the diagnosis has already been established by CT or MRI scan or other investigations, it is valuable to assess in which way the patient is affected in his mental functions, to advise him or her on problems that may be expected in everyday life situations such as family life and work, and to plan his/her rehabilitation.

Disclosure statement

No financial support and no other potential conflict of interest relevant to this article was reported.

Further reading

- Strub RL, Black FW. The mental status examination in neurology. 4th ed. Philadelphia: F.A. Davis; 2003.
- Schnider A. Verhaltensneurologie. Stuttgart: Thieme; 2004.
- Arciniegas DB, Anderson A, Filley CM, editors. Behavioral neurology & neuropsychiatry. Cambridge: Cambridge University Press; 2013.
- Godefroy O, editor. The behavioral and cognitive neurology of stroke. Cambridge: Cambridge University Press; 2013.
- Ettlin Th, Kischka U, Beckson M, Gaggiotti M, Rauchfleisch U, Benson DF: A Frontal Lobe Score: I: Construction of a mental status of frontal systems. Clin Rehabilitation (2000), 14:260–71.
- Wildgruber D, Kischka U, Fassbender K, Ettlin Th: A Frontal Lobe Score: II: Evaluation of its clinical validity. Clin Rehabilitation (2000), 14:272–8.

Correspondence:
Thierry Ettlin, MD
Professor of Neurology
and Behavioural Neurology
Medical Director
Reha Rheinfelden
Salinenstrasse 98
CH-4310 Rheinfelden
th.ettlin[at]reha-rhf.ch