Standardised Computer-based Organised Reporting of EEG (SCORE): a European consensus proposal

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SUMMARY:

The EEG signal has a high complexity, and the process of extracting clinically relevant features is achieved by visual analysis of the recordings. The inter-observer agreement in EEG interpretation is only moderate. This is partly due to the method of reporting the findings in free-text format.

The purpose of our endeavour is to create a computer-based system for EEG assessment and reporting, where the physicians would construct the reports by choosing from pre-defined elements for each relevant EEG feature, as well as the clinical phenomena (for video-EEG recordings).

A working group of EEG experts took part in a consensus workshop in Dianalund, Denmark, in January 2010. The faculty was approved by the Commission on European Affairs of the ILAE. The working group produced a consensus proposal, submitted afterwards to a pan-European review, organised by the European Chapter of the IFCN.

The main elements of SCORE are: personal data of the patient, referral data, recording conditions, modulators, background activity, drowsiness and sleep, non-ictal findings, “episodes” (clinical or subclinical events), physiologic patterns, patterns of uncertain significance, artefacts, polygraphic channels, and diagnostic significance. Specific aspects of the neonatal EEGs are scored: alertness, temporal organisation and spatial organisation.

Significance: SCORE can potentially improve the quality of EEG assessment and reporting; it will help incorporating the results of computer-assisted analysis into the report, it will make possible the build-up of a multinational database, and it will help in training young neurophysiologists.
INTRODUCTION

The inter-observer agreement in EEG interpretation is only moderate (van Donselaar et al. 1992; Stroink et al. 2006). The EEG signal has a high complexity. It depends on the intricate interplay between the activation of neural networks, localisation and orientation (Wong 1998) of the source (dipole), and its propagation throughout the brain (Lopes da Silva et al. 1993; Scherg et al. 1999; Flemming et al. 2005). Although certain aspects (like spike detection) can be automated, the whole process of extracting clinically relevant features cannot be computerized: it requires the assessment and interpretation of the recording by trained experts. Thus it is (to some extent) subjective and dependent on the abilities, training and experience of the reader (EEGer) (Stubbe et al. 1982). Another factor probably contributing to the inter-observer differences is the free-text format of the EEG descriptions. A recent study has demonstrated that the inter-observer agreement was consistently higher when the observers had to choose mandatory terms than when they could use optional ones (Gerber et al. 2008). When assessed for a relatively well-defined and restricted feature (like presence or absence of epileptiform discharges) the inter-observer agreement has proved to be beyond 80% (Stroink et al. 2006). However the EEG recordings are much more complex than to be described by a list of binominal measures. Free-text formats are flexible enough to reflect the various features extracted and weighted by the observers, but it can also lead to suboptimal assessment of the recordings: it does not prevent the observer from missing important features, it allows the use of terms not widely accepted (local terminologies), and makes it difficult to transfer the results of EEG assessment from one laboratory to another (for building of a multinational database).

The objective of our endeavour is to construct software for characterising EEG and ictal clinical events, where the physician chooses from pre-defined terms, simultaneously generating a rapport and filling information into a database. Our aim was: to improve the quality of the EEG assessment; to increase inter-observer agreement in reporting EEGs; to promote exchange of knowledge between EEG centres; to construct a multinational database for further research projects; to assist in education and training.

There have been several successful attempts in medicine to standardise the evaluation and reporting of complex clinical and/or electrographic patterns, for example the Unified Parkinson's Disease Rating Scale and the scoring of the polysomnography recordings using the AASM Manual for the Scoring of Sleep and Associated Events.

Previous computerised EEG reporting systems have been published (Aurlien et al. 1999; Finnerup et al. 1999). Robert R Young, Keith H Chiappa and their colleagues at Massachusetts General Hospital have in the 1980's used a locally developed software package for reporting EEG findings. Fixed terms could be selected and a report was semi-automatically generated (personal communication). Ronald Lesser and his colleagues at Johns Hopkins have been using a locally developed software package ("Reporter") since 1998 for reporting EEG findings. Since then they have prepared 38,000 reports using the software (personal communication). Although "Reporter" does not construct a formal database, terms in the EEG descriptions
are standardized, so that "keyword" searches can be used to help with a variety of needs, including construction of a database. However the previous attempts did not reach broad international acceptance. One of them seemed to be too time-consuming in the clinical practice (Finnerup et al. 1999) and it only built a database, but not a report. Harald Aurlien and his colleagues have been using software ("Holberg") for reporting EEGs and generating a database since 1998, and a modified version of this software has been used for reporting all standard EEG reports at the Danish Epilepsy centre since 2009. Totally, more than 36,000 EEGs have been reported using this software. The database that was automatically generated during the reporting, made possible to address specific issues related to certain aspects of the EEG, and this lead to three additional publications (Aurlien et al., 2004, 2007, 2009). However, these software packages remained in local use only. Probably the reasons for failing to reach a wider acceptance were the very different needs and traditions in different countries. To circumvent these problems, we tried to make the software as user-friendly as possible, and we tried to reach an international (in the first step a European) consensus on the structure and terms necessary for interpreting and reporting the EEG.

In January 2010, a working group of EEG experts took part in a consensus workshop in Dianalund, Denmark. The faculty of the workshop was approved by the Commission on European Affairs of the ILAE, and the event was advertised on the homepage of EUREPA (the education and research organisation of the CEA-ILAE). The SCORE working group, consisting of 25 clinical neurophysiologists / epileptologists from 15 European countries, elaborated a consensus proposal meant to reflect the needs and practice in different countries / centres. This consensus proposal was subsequently submitted to a pan-European review, organised by the European Chapter of the IFCN.

The SCORE working group followed the widely accepted international standards: we incorporated the available, relevant guidelines, consensus-statements and task-force proposals (Chatrian et al. 1974; Committee 1981; Daube et al. 1993; Gilmore 1994; Noachtar et al. 1999; Blume et al. 2001; Flink et al. 2002) as well as the terms described in authoritative EEG textbooks (Ebersole and Pedley 2003; Niedermeyer and da Silva 2005). We only added or modified them when absolutely necessary, based on published evidence and/or the consensus of the group. Because video-EEG recordings contain data on seizure semiology too, we attempted to include this into the structured report. If not specified otherwise, the terms in SCORE are defined as in Noachtar et al. 1999. The definitions for the terms used in SCORE are in the supplementary documents. In the software these definitions are directly available for each term.

**OVERVIEW**

Table 1 shows the main elements of SCORE, constituting the flowchart of data evaluation and interpretation. Elements 1-4 can be filled in by the EEG technician (physiologist), and later checked by the physician who interprets the recording. In the future, connecting the SCORE software with the patient administrative system
of the hospital / EEG department would help filling in these administrative data. Naturally, several recordings can be listed for each patient. Each recording has its own referral.

Elements 5-12 contain the main features assessed during the process of reading the EEG recordings (grouped in the software under “findings”). The list is long, because it is meant to contain all clinically relevant aspects that can occur during a diagnostic EEG recording. However, the software was designed in such a way that the user does not have to waste time on those features that do not occur in the recording. In other words, if an element/feature is not applicable for the recording to be described, one should not open it from the list.

The last element contains the overall interpretation of the recording, where the physician specifies the diagnostic significance. When this is done, a report is automatically generated, and the features scored by the user are fed into the database.

The terms in the main flowchart are defined in appendix-1.

PERSONAL DATA, REFERRAL AND RECORDING CONDITIONS

SCORE is installed and run within the hospitals IT system. The users have to make sure that the software is used according to the local regulations for safety of personal data. An “anonymisation” function will be available. This will remove all personal data from an entry, and only keep the scored EEG features.

The patient’s personal data (“patient details”) contain obligatory elements and optional ones. The obligatory elements are: identity number (“identity string” – in most countries this is given by the social security number), last name, first name, and date of birth. Optionally one can record the patient’s address and other details (under the entry: “notes”). For patients younger than 3 months, the option of recording the mother’s name instead of the first name of the patient is offered. For patients younger than 12 months, registering the gestational age is offered as an option.

In the next step, the recording conditions and the referral data are entered.

If the patient is younger than 3 weeks at the time of the recording, the software automatically switches to the special, neonatal features; between 3 and 5 weeks the physician can opt to use (or not) the neonatal reporting-matrix.

The recording conditions contain: start time, duration of the recording, EEG type (standard / sleep deprived / ambulatory recording / short-term video-EEG recording / long-term video-EEG monitoring / recording in the Intensive Care Unit), sensor group (10-20 system, 10-10 system). The sensor array can be customised for each centre, in the settings. The name of the technician, physician and supervision physician (if any) is selected here. The alertness of the patient is also registered: awake oriented – good cooperation or poor cooperation / disoriented / drowsy / asleep / stupor / comatose. Optionally the time of the patient’s latest meal can be added. Other aspects considered important for the recording can be detailed under “notes.
The “referral” part contains the following entries: referring unit, reason(s) for referral, diagnosis at referral (ICD10 list), latest seizure, medication (from the WHO list, with the possibility of specifying also medication withdrawal and medication administered during the recording). A list of choices is offered for the reasons for referral: epilepsy-related indications, other differential diagnostic questions, specific paediatric indications, follow-up EEG and other indication (table 2).

The options for the “latest seizure” entry are: “undetermined/unknown / < 1 hr / > 1 hr / < 1 week / < 1 month / longer than one month.

The list of provocation methods (“modulators / procedures”) performed during the recording conceptually belongs to the part with recording conditions. However, for technical reasons (programming) this is listed in the software as the first element of “findings”. This list contains: intermittent photic stimulation (IPS), hyperventilation, sleep deprivation, sleep (induced/natural / after sleep deprivation), awakening, medication administered during the recording, manual eye closure/opening, auditory stimulation, nociceptive stimulation, physical effort, cognitive tasks and “other modulators and procedures” (specified in free-text). Choosing hyperventilation prompts to the scoring of the quality of performance during this (insufficient or sufficient).

Until this point the data can be entered by the technicians / physiologist.

“SCORING” THE EEG

Elements 5-12 are grouped under the heading “findings” in the SCORE software (Table 1 and Appendix 1). While reading the EEG, the physician “scores” the relevant features of the recordings using these entries. It follows the way electroencephalographers describe the EEG recordings. The first two elements contain the features of the “ongoing” EEG activity during wake period (“background activity”) and during drowsiness and sleep. Non-ictal findings depict all the graphoelements / EEG patterns that are considered abnormal, and that are not a part of the ongoing (background) activity, and that are not the EEG manifestation of a seizure / clinical episode. We opted for the term non-ictal, instead of “inter-ictal” because that would suggest that the patient/recording also had an ictal finding. The element “episodes” contains the clinical and EEG features of the seizures and other clinical / ictal events. Patterns of uncertain significance, physiologic patterns, artefacts, and polygraphic channels can also be scored, if relevant / applicable. In the end, the electroencephalographer scores the global interpretation / diagnostic significance of the recording. Finally a report is automatically generated.

BACKGROUND ACTIVITY

Background activity contains three main sub-chapters: posterior dominant rhythm, other organised rhythms and special features. The definition of the terms is detailed in appendix 2.
Table 3 shows the features (in bold) that can be scored for the posterior dominant rhythm (alpha rhythm in adults) and the corresponding choices for each of them. For each recording the posterior dominant activity only can be scored once. The electroencephalographer can score here the global interpretation of the posterior dominant activity for the patient (taking into account the age and the state of consciousness). The following choices are available: normal, abnormal, no definite abnormality, not possible to determine. To speed up scoring of most recordings, a short-key re-directs the flow-chart to the window where frequency of the posterior dominant rhythm can be specified.

Other organised rhythms (besides the posterior dominant rhythm) can be selected. Here several entries are permitted (i.e. several types of “other organised rhythms” can be selected and successively scored for each recording). First, one has to choose a name of the rhythm: alpha, beta, mu, delta, theta. Then the localisation has to be specified (see below). The extent (i.e. percentage of occurrence during the recording) and the reactivity to external stimuli (yes/no) can be selected. The electroencephalographer can score here the interpretation of this rhythm (taking into account the age and the state of consciousness) as: normal, abnormal, no definite abnormality.

The last sub-chapter for the background activity is: “special features”. This contains three entities: electrocerebral inactivity, generalised suppression-burst and suppression of the background activity. Selecting “electrocerebral silence inactivity” makes it impossible to score any additional feature, except for “artefacts” and “diagnostic significance”. Selecting “generalised suppression-burst” prompts to the scoring of the duration of the bursts and (separately) the duration of the suppression. Selecting “suppression” prompts to the scoring of the duration of this. In the next step one can specify whether these entities are modulated (influenced) by external stimuli / interventions: passive eye opening, auditory stimuli, administered medication. The possible choices are: increase, decrease, unmodified, triggered by, stopped by, and “not possible to determine”.

**SCORING THE LOCATION**

Different entries (“features”- i.e. EEG patterns, graphoelements) have “location” as an attribute. This is described by laterality (left / right / midline /bilateral / diffuse) and regions (frontal, temporal, central, parietal, occipital). Scoring “laterality” and “regions” prompts (based on the sensor-settings specified in the recording conditions) a list with the sensors corresponding to the selected side and region. Form this list, individual electrodes can be unselected, and the maximum of the field potential can be specified (by choosing one or more electrode names).

For bilateral localisations, additional 2 features, the amplitude asymmetry and the bilateral synchrony have to be scored. The choices for amplitude asymmetry are: symmetrical, consistently more pronounced on the left side (>50% difference), consistently more pronounced on the right side (>50% difference), shifting side-preponderance, not possible to determine). The choices for synchrony are: asynchronous, primary bilateral
synchrony, secondary bilateral synchrony (propagation from left to right / from right to left) and cannot be determined.
The so-called “generalised” discharges are scored by choosing: “bilateral” + “synchronous” + name of the region.
“Diffuse” denotes a location of an EEG pattern (rhythm) that occurs in all or most of the regions, on both sides, but asynchronously.
If a graphoelement (transient) is seen asynchronously in more than 2 locations, than “multifocal” can be selected as a descriptor of localisation.
Traditionally, the location of the EEG patterns/ graphoelements is described by specifying the scalp regions (or electrodes) where the negative potentials are recorded. However, by visual assessment of the distribution of the negative and positive potentials on the scalp (voltage map) the brain region containing the source can be estimated. Optionally this can be registered as a location-descriptor. Choices for “brain-regions” (and sub-regions in the brackets) are: frontal (perisylvian-superior surface; lateral; mesial; polar; orbitofrontal), temporal (polar; basal, lateral-anterior; lateral-posterior; perisylvian-inferior surface), central (lateral convexity; mesial; fissural-anterior, fissural-posterior; opercular), parietal (lateral-convexity; mesial; opercular), occipital (lateral; mesial) and insula.

**SLEEP and DROWSINESS**
The features of the “ongoing” activity during sleep are scored just following the “background activity”. If abnormal graphoelements appear, disappear or change their morphology during sleep, that is not scored here but at the entry corresponding to that graphoelement (under modulator/ sleep). Giving a detailed description of sleep such as in polysomnography recordings is not the scope of this SCORE element. However, the features considered clinically relevant in an EEG recording are listed. The following entries can be selected: sleep architecture, normal sleep patterns, hypnagogic or hypnopompic hypersynchrony in children, SOREM (sleep-onset rapid eye movement sleep), abnormal asymmetry or absence of sleep graphoelements, non-reactive sleep activity. Appendix 3 contains the definitions for these terms.
Sleep architecture can be scored as normal / abnormal / not possible to determine. For “normal sleep patterns” the sleep stages reached during the recording can be specified (N1; N2; N3; REM; not possible to determine). For the absence of sleep graphoelements, the name of the graphoelement (sleep spindles / vertex sharp transients / K-complex / POSTS / other) and the location where the graphoelement is absent or reduced (see scoring the localisation) is specified. Significant asymmetry of the sleep spindles can be registered and the location (where it is reduced) can be specified.
Several successive entries can be selected and scored for “sleep”.
NON-ICTAL FINDINGS
Each non-ictal finding is characterised by 4 attributes (“features”). Three of them are obligatory: name of the graphoelement, localisation and temporal features. The fourth one (“modulators”) is optional (is only scored if it applies to the observed finding).

The names of the non-ictal graphoelements are listed in table 4 and defined in appendix 4. They are classified into four groups to make it easier to find the name in the list.

The location is scored as described above.

The time-related features of the non-ictal findings are: discharge pattern, mode of appearance and incidence. “Discharge pattern” characterises the time-related features within the discharge. The choices are: single discharges, rhythmic trains/bursts and arrhythmic trains/bursts. The frequency (range) is specified for the rhythmic bursts by entering the corresponding numbers (Hz). The duration (range) is specified for the trains/bursts. As some graphoelements might have more than one type of discharge pattern within a recording, multiple choices are allowed here.

“Mode of appearance” depicts how the non-ictal EEG patterns / graphoelements are distributed throughout the recording. The choices are: random, periodical, variable and not possible to determine. If “periodical” is selected, the duration (range) of the inter-discharge interval can be specified.

“Incidence” characterises how often the described non-ictal finding is seen throughout the recording. For the single-discharges, the suggested choices for “incidence” are: only once, < 1 / min., 1-3 / min.,4-6 / min., > 1 / 10 seconds and continuous. For the trains/bursts the incidence is expressed as the estimated percentage of the total duration of the bursts during the recording (<1%, 1-10%, 10-50%, 50-90%, >90%).

Modulators. Some non-ictal findings are influenced by external stimuli / interventions. These can be described as the fourth feature: “modulators”. The choices for eye-closure sensitivity are: yes and no. For the IPS the choices for photoparoxysmal response are: posterior stimulus-dependent response, posterior stimulus independent response (limited to the stimulus-train / sustained), generalised photoparoxysmal response (limited to the stimulus-train / sustained), as suggested by Kasteleijn-Nolst Trenité et al. (2001). In addition, “activation of preexisting epileptogenic area” can be selected as a choice for IPS (Kasteleijn-Nolst Trenité et al. 2001). For the other modulators the following choices are available in SCORE: increase, decrease, unmodified, only during this modulator, not possible to determine. For “sleep” two additional choices are available: “change of pattern during sleep” - for making possible to describe qualitative changes too (besides the quantitative changes described above), and “continuous during NRS” to score for CSWS/ESES (the percent is than typed in the free-text box).

Several, distinct non-ictal findings can be scored independently / successively.

EPISODES
This element of SCORE contains the descriptors of the clinical episodes and for electrographic seizures.
The main parts of this element are: name of the clinical event, timing & context, effect of interventions, and electroclinical findings.

The names of the episodes can be selected from the list showed in table 5:
The table includes ILAE seizure classification (Commission 1981; Berg et al. 2010). Focal seizures can be further classified according to the presumed localisation, and it can be specified whether they evolve to bilateral convulsive seizure. (Impairment of consciousness is scored in the next step).

“Timing and context” covers the following features: incidence (“episodes / recording”), time at start, duration of the episode and of the postictal phase, prodrome, state of wakefulness at the seizure start, impairment of consciousness during the seizure, provocative factors, facilitating factors, tongue biting, effect of medication and time relationship between clinical and EEG start.

To reflect the clinical practice, SCORE makes possible to group, and describe several clinical episodes (seizures) under the same heading, if the physician considers them as manifestation of the same phenomenon. However, as a minimum, the seizure onset has to be identical in all the clinical episodes described under the same heading. If several clinical episodes are described together, the number of such episodes during the recording, and the time of their start have to be documented. For the cases where the precise number of the clinical events cannot be determined, this is included as a choice (“not possible to determine”).

The duration of the clinical event (seconds) is registered. If several clinical events are described under the same heading, the range is registered (one enters 2 numbers). The option “> 30 minutes” is given, if the precise length cannot be determined.

The prodrome (if any) can be selected, and then described in free text. Prodrome is a preictal phenomenon, and it is defined as a subjective or objective clinical alteration (e.g., ill-localized sensation or agitation) that heralds the onset of an epileptic seizure but does not form part of it (Blume et al. 2001). Thus, prodrome should be distinguished from aura (which is an ictal phenomenon).

One can specify whether the clinical event started from sleep or from wake state. The impairment of consciousness during the seizure (affected / mildly affected / not affected / not possible to determine) can be scored here.

The facilitating factors (if known) can be selected: alcohol, awakening, catamenial, fever, sleep, sleep-deprivation, other (free text). Facilitating factors are defined as transient and sporadic endogenous or exogenous elements capable of augmenting seizure incidence (increasing the likelihood of seizure occurrence). The provocative factors (if known) can be selected from the list: hyperventilation, reflex (+ free text), other (+ free text). For IPS a list is offered to select the type of photoparoxysmal response (see under: “modulators”). Provocative factors are defined as transient and sporadic endogenous or exogenous elements capable of evoking/triggering seizures immediately following the exposure to it.

Tongue biting can be selected and registered.
In this part one can specify whether the clinical start precedes the EEG start or the other way around. The time (in seconds) between the clinical and EEG start can be documented by entering the corresponding number.

**Effect of interventions**

If medication was administered during the clinical event (for example to stop an epileptic seizure) than the effect of medication can be scored: clinical effect (yes / no / not possible to determine) and the EEG changes (decrease / cessation / no change / increase / not possible to determine). Duration of the changes induced by medication administered during the recording (range) can be entered here.

**The electroclinical findings** (i.e. the seizure semiology and the ictal EEG) are divided in 3 phases: onset, propagation and postictal. For simple / short seizures the whole seizure can be described under “onset”.

Within the onset period several clinical signs can be registered, but this implies that they occurred simultaneously. For the propagation phase, several clinical signs / ictal EEG patterns can be selected, and their chronological order of appearance can be specified. As the elements of the propagation might vary within the group of clinical episodes described under the same heading, the number of ictal events in which that particular element occurred can be specified. Otherwise the scoring of the onset and propagation phase is identical.

**The clinical signs** are described by a name and the body-localization where it is observed. The list with the names (table 6) corresponds to the ILAE Commission Report: Glossary of Descriptive Terminology for Ictal Semiology (Blume et al., 2001).

Somatotopic modifiers describe the part of the body where the clinical sign is manifested (Blume et al., 2001). For some of the clinical signs (for example dacrystic, gelastic) the name determines the body part too. For others this has to be selected from the list of choices: generalised (yes/ no), laterality (Left / Right / Bilateral – Symmetric / Left>Right / Right>Left), body part (Eyelid / Face / Arm / Leg / Trunk / Visceral / Hemi-) and the centrality (Axial / Proximal limb / Distal limb).

Clinical and behavioural signs of ictal cognitive disturbances should be examined and recorded by testing with a standardized protocol assessing the state of consciousness (reactivity and orientation), memory, speech or language, motor and other neurological functions of the patient (Velis et al, 2007).

**The ictal EEG pattern** is described by its name and the localisation. The names selectable for ictal patterns are shown in table 7 and defined in appendix 5. Where indicated, frequency (Hz) and amplitude (µV) values can be specified by entering the corresponding numbers.

The localization for these patterns is scored as described above.

For the postictal phase, the list of clinical signs and the list of EEG patterns is different from the onset and the propagation phases. The possible choices are shown in table 8. The postictal EEG patterns are defined in appendix 5. The names of the clinical signs are selected from the list according to the ILAE Commission Report: Glossary of Descriptive Terminology for Ictal Semiology (Blume et al., 2001).
In the postictal period, the clinical signs have as attribute the somatotopic modifiers. The names of the postictal EEG patterns have localization as an attribute (similarly to the onset and propagation phases).

**PHYSIOLOGIC PATTERNS AND PATTERNS OF UNCERTAIN SIGNIFICANCE**

These items are not considered abnormal, and they are only scored if the physician finds a clinical relevance for it (for example emphasising that they are not abnormal / correcting the previous scoring of a junior physician, etc.). Patterns of uncertain significance contain graphoelementnts/ EEG patterns that resemble abnormal ones, but in most of the cases they are not associated with a pathological process (“normal variants”).

These items are described by 2 features: the name and the localisation. The list of the names and their definitions are in appendix 6. Localisation is described as detailed above.

**EEG ARTEFACTS**

In this SCORE element one can document the names (appendix 7) and localization of the artefacts, and one can estimate the consequence of the artefacts on the recording (recording is not interpretable because of the artefacts / recording of reduced diagnostic value due to artefacts / does not interfere with the interpretation of the recording).

**POLYGRAPHIC CHANNELS**

In this part one can register the features related to the additional (polygraphic) sensors: ECG, respiration measurements, EMG. The possible choices are shown in table 9. Values (numbers) are entered, where specified in the brackets.

**DIAGNOSTIC SIGNIFICANCE**

Before generating the report, the physician has to put the scored EEG features into the clinical context. The diagnostic significance of the recording offers 3 choices: normal, no definite abnormality and abnormal. If abnormal is selected, one has to specify it in more detail (table 10).

For “epilepsy” further scoring of significance is available. The entries that can be selected here (focal vs. multifocal vs. generalised, and idiopathic vs. symptomatic) do not constitute the classification of epilepsies, but rather highlight the additional diagnostic information the EEG can provide in the corresponding clinical context.
In this part one can score the changes since the last (previous) EEG: no change / improved / worsened.

**GENERATING THE REPORT**

When the scoring is done, the report is automatically generated. The physician can review, edit or change any part of the scoring until the report is generated. In the report-generating window, free-text parts can be added, and a text-box for “summary” can be filled in.

**SPECIFIC ASPECTS OF THE NEONATAL RECORDINGS**

For newborn babies (neonatal period = first 28 days after birth) the gestational age (GA) at birth is specified, and the gestational age at the time of the recording is calculated. A specific neonatal matrix is loaded instead of the “background activity” and “sleep”. This matrix contains the specific features of the neonatal ongoing activity and the characteristic transients.

The main elements are: behavioural stages (alertness), temporal organisation and spatial organisation. For each entry (choice) of the behavioural stage, one can attribute temporal organisation and subsequently spatial organisation. These are scored further by their specific features. Temporal organisation characterises the changes in time of the ongoing EEG activity. The spatial organisation codes the characteristic neonatal EEG patterns (also including transients), and their parameters - including location.

For all features scored within the temporal and spatial organisation, the electroencephalographer has the possibility to label them as “considered normal for age” or “considered abnormal for age”.

The content of (selectable terms for) “behavioural stages” and “temporal organisation” of the neonatal matrix is different for the conceptual age <30 weeks and >30 weeks (table 11). Definitions for the neonatal terms are presented in appendix 8.

**Temporal organisation**

If “isoelectric EEG” is selected, no further scoring is available within the neonatal matrix (only “artefacts”, “polygraphic channels” and “diagnostic significance” can be scored). If continuous tracing (tracé continu) is selected, no further specifications for the temporal organisation are available in this entry. If discontinuous tracing (tracé discontunu), tracé alternant or suppression-burst is selected, this has to be further characterised by the “duration of low-voltage interval (interburst interval)” and the “duration of electric activity (bursts)”.

**Spatial organisation**

“Spatial organisation” is attached for each entry in “temporal organisation” (except for “isoelectric EEG”). This contains: the name of the EEG pattern / graphoelement (table 11), frequency and amplitude entries, a localisation-descriptor (including also bilateral synchrony and amplitude asymmetry descriptors, as detailed above), incidence, and reactivity. As for the temporal organisation, for the spatial one the physician has the
possibility to label it as considered normal or abnormal for age. Reactivity is scored as yes/ no (the type of stimulus can be specified here in a free text entry).

If “discontinuous tracing with non-physiologic bursts” is selected, that means that the EEG patterns during the period of the electric activity are considered “abnormal”. In this case the list of “names” offered is not the one presented in table 11, but the one presented in table 3 (non-ictal patterns).

There is an option for a “simplified” description of the spatial organisation, which only contains a global assessment of the significance and the reactivity of all graphoelements attached to that entry.

THE SOFTWARE

Based on the consensus-workshop organised in Dianaland, Denmark, in January 2010, the software containing the features described above has been developed by a group of programmers at the Holberg EEG AS. The programming work was organised and supervised by one of the authors (Harald Aurlien), and, during this process, the content of the software was repeatedly compared and synchronised with the SCORE consensus-proposal by another author (Sándor Beniczky).

A free version of the SCORE software and a detailed guidance for users can be requested from the following home-page: http://holbergeeg.com

The software automatically generates a report and saves the scored features in a local database.

FUTURE PERSPECTIVES

In the current version of the software a database is produced locally. We plan to make an international database, where centres wishing to participate can upload their data, after appropriate processing (removing) of personal data. The legal background for data transfer has to be clarified before proceeding to this (rules and regulations unfortunately differ even within the European Union). Such an international database would constitute a valuable tool for further research projects, as search-criteria can be constructed to verify hypothesis or extract relevant information from the database. In addition the software makes it possible to compare the scored features in the report with a scored “second opinion” from another laboratory on an EEG laboratory. This offers the tools for quality control and audit.

SCORE would be helpful in bridging the gap between the classical method of visual analysis of the EEG and the advanced (computerised) analysis methods. The appropriate analysis tools can be attached to the corresponding elements of SCORE (for example quantitative EEG analysis method for “background activity”; source analysis methods for the “localisation descriptor”, etc). The electroencephalographer can enrich with these methods his armamentarium for the analysis and interpretation of EEG recordings in the clinical practice, by integrating their results in the standardised EEG report.
Integration of SCORE with the patient administration systems of the hospitals is going to save considerable time and increase the feasibility.

The terms/features used in SCORE are provided with a definition in the current version. The intention of the SCORE consortium is to provide (besides the definition) typical examples of EEG samples (screen-shots) showing the various features. Thus, besides the definition, an EEG sample will be accessible directly (from the feature in question) in the software - the user will be able to open this while scoring the EEG. We consider that this has a remarkable potential in training neurophysiologist.

In addition to EEG, MEG data will be integrated for standardized analysis in collaboration with the European Clinical MEG Society (EMEGS).

Unfortunately most of the terms and features of the EEG report are based on tradition, and systematic evaluations of their diagnostic significance are not yet available. An international EEG-database would help in further, evidence-based evaluation (and ultimately selection) of the features traditionally included in the EEG report. Therefore, we plan a periodical revision of SCORE, based on these data, and on additional, incoming suggestions and comments.

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