Technical contribution

AN OPTICAL SCAN SYSTEM FOR ENCODING AND TABULATION OF VISUALLY SCORED SLEEP DATA

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Most systems for visual scoring of all-night sleep records recommend scoring by successive epochs or pages of record. These typically range in duration from 20 sec to 1 min (Feinberg et al. 1967; Rechtschaffen and Kales 1968; Williams et al. 1974). A given epoch may receive more than one score (for example, stage 1 EEG with eye movement or body movement, etc.). Thus, the record of a single night might consist of 1500 20-sec epochs of record (500 min) which, with multiple scores, could generate 2000–2500 data entries. Since subjects in sleep investigations are typically studied over several nights within a single condition, a massive volume of data rapidly accumulates.

A major obstacle to computer analysis of visually scored sleep data has been the time, expense and the possible error involved in introducing this voluminous information into the computer. A number of systems have been developed in an attempt to systematize the tabulation and data analysis of visually scored sleep data (Anders and Zangen 1972; Tassone et al. 1973; Stanley 1974; Walker and Reite 1976). All of these systems require input of the visually scored sleep data as an operation separate from the visual scoring. In addition, these systems do not have the dual capability of retaining the original data by individual polygraph sleep data (PSD) page and the indexing of events in real time. This capability permits the integration of visually scored sleep staging with computer analyses of the EEG wave form (Feinberg et al. 1978).

We present here a new system—OPSCAN—which overcomes these limitations. It consists of two parts. The first part is an input system in which specially designed scoring sheets are optically scanned and data directly entered into the computer. However, these entries must be monitored by the operator since the OPSCAN sheets sometimes contain human error. To facilitate this monitoring, we have included extensive error and edit-checking as described below. The second part consists of a data base for the visually scored PSD. The visually scored data base (VSDB) is organized by NREM and REM periods but retains within those units the original coding of each epoch (PSD page) of sleep. Organization of data by REMPs and NREMPs has proved both efficient and informative in previous studies (Feinberg et al. 1967; Feinberg 1974; Feinberg and Floyd 1979).

We thought the OPSCAN programs might be useful to other investigators. For this reason, those variables which often differ among laboratories (number of seconds per PSD page, length criteria for NREM and REM periods, etc.) were made specifiable program parameters. From the optically scanned input, with 3 additional cards of key punched data, the OPSCAN system yields scores for virtually all sleep variables. Data are provided both for the entire night and for successive NREM and REM periods. All data are entered directly into the Statistical Package for the Social Sciences (SPSS) (Nie et al. 1975) for analysis. Among the analyses we routinely include are the computation of means and standard deviations, both by cycles across the nights and by nights within and across conditions; the testing for trends within nights and for differences across conditions in both cycle trends and all-night mean values.

The program described above could prove useful to any laboratory engaged in the visual scoring of all-night sleep records. In addition, by establishing an intermittent correspondence between real-time and PSD page (e.g., using a time-code generator or wall clock) the VSDB can be indexed by real-time and real-time correlates of specific PSD pages can be sought. For example, we have developed programs that combine the VSDB with our period-amplitude analysis data base (Feinberg et al. 1978) also indexed in real time, enabling us to examine the wave form characteristics of record visually classified as stages 2, 3, 4, NREM or REM. An additional advantage to the use of a highly accurate and uninterrupted time

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code is that it permits us, in our indexing of the VSDB, to account for both variations in paper speed and gross time disruptions of the PSD record.

Methods

(A) Input

There are two forms of input to the VSDB system.

(1) Optical scan sheets are used to input the visually scored data. Fig. 1 illustrates the scan sheet format. The scan sheets are organized by PSD page. Fifty pages of PSD are encoded on a single scan sheet. Each row of the scan sheet denotes a specific page of the PSD. The PSD record is visually scored directly on scan sheets. This procedure eliminates the need for separate transcription of the original data. Only changes in sleep stage are encoded reducing the number of entries required. Approximately 30 scan sheets are generated for an 8.5 h PSD record at the paper speed (15 mm/sec) we employ. Occasionally (once or twice/30 pages) the REM optical mark reader has failed on scan sheets. To deal with this change is marked for two editing program checks for system ensures a reliable information and monitors reliability.

(2) For each complete night a second input consists of cards which code subject information, time-code/PSD record. The PSD page/time-code is accomplished by selecting section in which there are no time breaks for each page and time-code are entered for each page. Occasionally (once or twice/30 pages) the REM sheet data are treated as an input. The first program recognizes the scan sheet correspondence record. It is at this point that the scan sheet data are no longer utilized.

(B) Processing

The scan sheets are read by a computer terminal, These machines are available at a university computer center where grading of exams. The optical mark reader has fail and are used as an input. The first program sheet images from the computer, the scan sheet corresponding to the present time code. The page/time-code includes checks for missing data and signals the presence of an input. This program can examine the events (e.g., eye movements) and area in the REM complex and spindle activity. Within a time of occurrence (or page) time code for each epoch, the NREM or REM period. Within each start, awakenings and phasic events, twitches, eye movements, and REM periods. Within the epochs, selected variables are coded and indexed both VSDB (epochs of awakenings) and REM periods. Within each epoch, the NREM or REM period. Within each epoch, the NREM or REM period. Within each epoch, the NREM or REM period. Within each epoch, the NREM or REM period. Within each epoch, the NREM or REM period. Within each epoch, the REM period.
optical mark reader has failed to sense marks on the scan sheets. To deal with this problem, each stage change is marked for two consecutive pages and the editing program checks for this double coding. This system ensures a reliable picture of the PSD scoring information and monitors the optical mark reader’s reliability.

(2) For each complete PSD record (i.e., an entire night) a second input consists of 2-3 keypunched cards which code subject identification, experimental conditions, time-code/PSD page correspondence, etc. The PSD page/time-code correspondence is accomplished by selecting sections of the ink-written record in which there are no time disruptions. The PSD page and time-code are entered for the beginning and end of each such section. The difference in time codes between the end of one section and the beginning of the next section specifies the length of any disruptions (paper changes, snags, etc.) of the PSD record. If no time codes are entered, the PSD scan sheet data are treated as one continuous section.

(B) Processing

The scan sheets are read by the IBM optical mark reader. These machines are usually available at university computer centers where they are used for the grading of exams. The optical mark reader generates two column binary cards for each scan sheet. The column binary cards are read into the OPSCAN system as an input. The first programs reconstruct the scan sheet images from the column binary cards and edit the scan sheet corresponding to each night of the PSD record. It is at this point that human error in marking scan sheet data is detected and corrected. The editing process includes checks for misplaced and/or misordered scan sheets and signals the occurrence of unlikely events (e.g., eye movements in stage 4 sleep). The operator can examine the edit/error messages and, depending upon the seriousness of the problem, interrupt the program to correct scan sheet errors or permit processing to continue.

Processing continues by merging the reconstructed and edited PSD records with the identification and (if present) time code information. Data are next indexed by time-code (if provided) and abstracted into records which correspond to successive NREM and REM periods. Within each record, stage changes, awakenings and phasic events such as body movements, eye movements in stage 4 sleep, and REM period during which it occurs. Selected variables are then extracted from the VSDB (epochs of awakening, stages 2, 3, 4 and REM; number of stage changes; phasic events such as eye movements, body movements and twitches during each REM/NREM period, latencies of REM activity, sleep onset and delta, etc.) and transferred to the SPSS system where a set of standard statistical analyses are performed. These analyses include trend analyses across cycles, comparisons of all-night values across conditions, computation of within-subject reliabilities and analysis of cycle trend by condition interactions. In addition the data are, of course, readily accessible for other specialized analyses.

Thus, OPSCAN provides for the encoding, tabulation and statistical analysis of visually scored PSD. The only manual operations are in the visual scoring and the 2-3 cards of key-punched data. All further tabulation, reorganization and analyses of data are done by computer. The VSDB provides a permanent, easily retrievable record of the scoring of each consecutive PSD page organized by NREM and REM periods. This data base will ultimately be used to describe the frequency distributions of REM and NREM occurrences; such distributions can provide rational criteria for NREM and REM lengths (e.g., mean ± 2 S.D.s). In our laboratory, the integration of these data with the output of the computer analysis of EEG wave forms is of further value.

All of the programs are written in PL/I IBM OS 360/70 and require less than 120K of core for execution. The cost of processing a single night’s PSD is less than $6.00.

Discussion

Sleep studies are inherently expensive. It is, therefore, important to economize where possible and to extend and maintain in retrievable form as much of the information obtained as possible. The OPSCAN system virtually eliminates the expense of manual tabulations and retains the visually scored sleep data in permanently accessible form.

Many sleep laboratories, including our own, are carrying out computer analyses of sleep EEG wave forms. Typically, results of such analyses are presented in parallel with the results of visual sleep stage scoring. A second advantage of the OPSCAN system is that because of real time indexing of visually scored events, it becomes possible to carry out direct comparisons of the visually scored and computer measures.

These programs are available at cost to interested investigators. We will provide source and load modules of all programs on magnetic tape together with user documentation and sample output illustrating the complete analysis of 2 nights of PSD record.
Summary

A system for computer-assisted encoding, tabulation and analysis of visually scored sleep data is presented. The main features of the system are:

1. The use of computer-readable optical scan sheets for direct encoding of the sleep data. This eliminates the need for a separate transcription and/or key-punching operation.

2. The development of a visually scored data base, organized by NREM and REM periods, which contains all items of visually scored data indexed by time and/or page of occurrence in the sleep record.

The advantages of this new system are: (a) the low cost per night of operation; (b) the facilitation of analysis of cycle phenomena and testing of new hypotheses that would usually involve tabulation of the data; and (c) the facilitation of analysis of real-time correlates of visually scored sleep stages.

Résumé

Système de balayage optique pour coder et marquer les stades de sommeil scores visuellement

Les auteurs présentent un système assisté par ordinateur pour coder, mettre en tableau et analyser des données de sommeil scores visuellement. Les principales caractéristiques de ce système sont:

1. L'utilisation de bordereaux destinés à être lus par l'ordinateur par balayage optique, pour codage direct des données de sommeil. Ceci élimine la nécessité d'une transcription séparée et/ou d'opérations d'entrée sur clavier.

2. Le développement d'une base de données scores visuellement, organisée par périodes de sommeil lent et de sommeil paradoxal, qui contient tous les items des données scores visuellement, indexées en fonction du temps et/ou de la page où elles surviennent dans le tracé de sommeil.

Les avantages de ce nouveau système sont: (a) le coût peu élevé par nuit ou par opération; (b) la facilitation d'analyse des phénomènes de cycles et la possibilité de tester de nouvelles hypothèses qui impliqueraient habituellement la remise en tableau des données; (c) la facilitation de l'analyse des corrélats en temps réel des stades de sommeil visuellement scores.

References


Eletroencephalography © Elsevier/North-Hollan

Technical contributk

A STATIC CHARGE MOVEMENTS DURING SLEEP

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The normal motor patterns of many different kinds of movements (ballistography, actography) have been used in several studies. The sensitivity of individual consistency sleep percentage (r = 0.45). However, the correlation between the total number of movements per night and the number of body movements is one of the main findings of the study. The correlation coefficient was 0.45 (r = 0.45). However, the correlation between the total number of movements per night and the number of body movements is one of the main findings of the study. The correlation coefficient was 0.45 (r = 0.45). However, the correlation between the total number of movements per night and the number of body movements is one of the main findings of the study. The correlation coefficient was 0.45 (r = 0.45). However, the correlation between the total number of movements per night and the number of body movements is one of the main findings of the study. The correlation coefficient was 0.45 (r = 0.45). However, the correlation between the total number of movements per night and the number of body movements is one of the main findings of the study. The correlation coefficient was 0.45 (r = 0.45). However, the correlation between the total number of movements per night and the number of body movements is one of the main findi...