Automatic Sleep-Wake Stage Scoring using Artificial Neural Networks: Optimisation and Comparaison of two Systems

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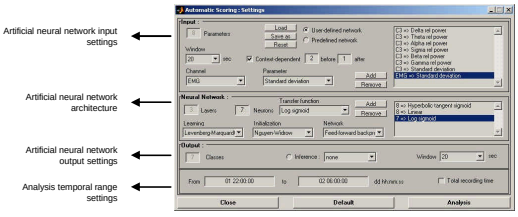
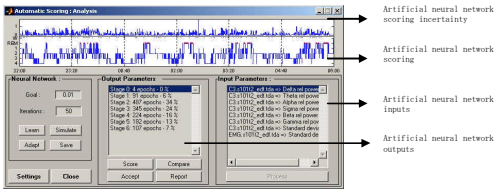
In human and animal, artficial neural networks have shown satisfying performance as compared to human experts in sleep-wake stage scoring analysis of polysomnographic (PSG) recordings (1-2). To date, the few available analysis sytems cannot be used with any recordings because they have been developped using fixed parameters. These parameters consists in the number, type (EEG ± EMG ± EOG) and sampling rate of signals required, the recording device and digital file format used for data storage, as well as the number of sleep-wake stages to be determined.

A new software system for off-line polygraphic reviewing and analysis (3; **PRANA**, *PhiTools, Strasbourg, France*) has been developed under MATLAB (*The MathWorks, Natik, USA*). This environment, which supports virtually any recording systems, serves as a basis for developping and testing new analysis and detection algorithms since it allows incorporating user software plug-ins. By doing so we have developped an automatic sleep-wake stage scoring analyser allowing to configure, learn and simulate artificial neural network classifiers. In its original version this automatic analyser software plug-in showed a globall agreement of 74±7 and 80±1% in scoring healthy human and rat recordings, respectively (4).



Settings interface of the **PRANA software** a**utomatic sleep-wake stage scoring plug-in**.

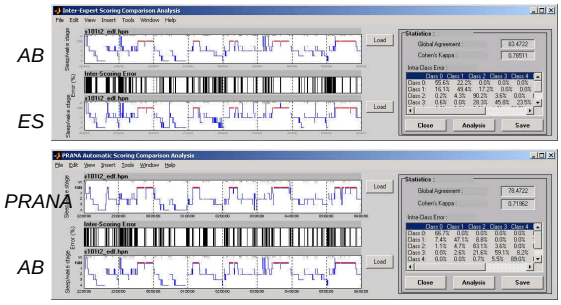


Scoring interface of the PRANA software automatic sleep-wake stage scoring plug-in.

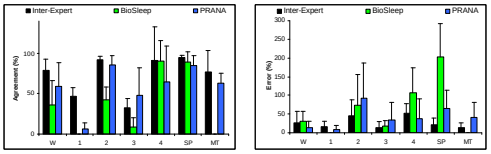
Objective: The aim of this study was to optimise the **PRANA** software automatic analyser plug-in for healthy human sleep-wake recordings and to compare its performance to that of another commercially available system (**BioSleep** *v3.0 Oxford BioSignals, Oxford, Royaume-Uni*). The parameters taken into account in the optimisation process were the use of a consensual multi-individual learning database, on one hand, and the introduction during simulation of a contextual dependency, on another hand.

Material & Methods: Nocturnal PSG recordings performed in 13 young adult healthy volunteers were interpreted independently by two experts (ES and AB) according to the standard R&K criteria (5), then submitted to automatic analysis by the two compared systems. Global and intra-class agreement (specificity) and error (sensibility) between experts and automatic systems were determined and evaluated using Cohen's kappa statistics (6).

Results: Comparison of the two systems against the experts indicate better performances for the **PRANA** system than for **BioSleep** (global agreement of 79.5±6.3 *versus* 46.2±8.7%). Intra-class agreements and errors are represented in the accompanying figure.



Scoring comparison interface of the PRANA software automatic sleep-wake stage scoring plug-in.



Intra-class agreement and error (mean±SEM) of two automatic anlysis systems (PRANA and BioSleep) compared to the analysis of two experts.

Conclusion: A global perfomance of the **PRANA** system just below inter-expert agreement (82.8±3.3%) suggest the use of the system at the sleep lab.

The **PRANA** software automatic sleep-wake stage scoring plug-in, by allowing to configure, learn and simulate various type of artificial neural network classifiers, may represent a convenient tool to speed up human and animal sleep research.

Since it allows incorporating user software plug-ins, the **PRANA** software system, which supports virtually any recording systems, may serve as a basis for developping and testing new analysis and detection algorithms.

References: **(1)** Schaltenbrand et al., *Sleep* 19(1):26-35, 1996. **(2)** Robert et al., *J Neurosci Methods* 79(2):187-93, 1998. **(3)** Tung and Oxenford, *The MathWorks newsletter*, Spring 2001. **(4)** Becq et al., *16ième Congrès de la SFRS,* 2001. **(5)** Rechtschaffen and Kales, *US Government Printing Office*, 1968. **(6)** Cohen, *Educ Psychol Meas* 20:37-46, 1960.