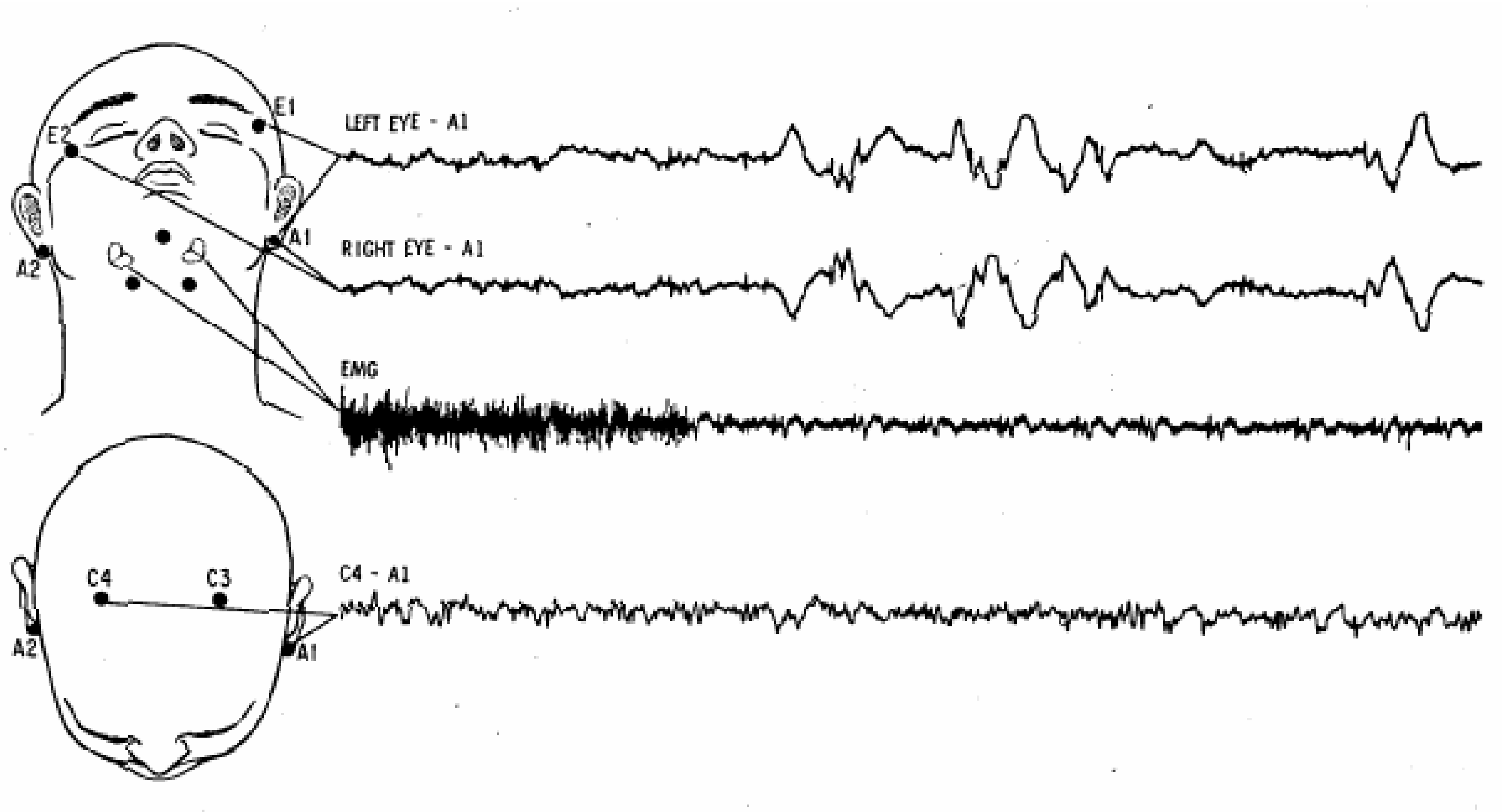
Kapitel 8: Beispiele aus der Praxis

Ack: Dank an Doz. Dr. Peter Anderer zur Verfügungstellung einiger Folien

Beispiel – Polysomnographie / Schlaf-EEG



Stage (per 30 s epoch):

Stage Wake

Stage 1
Stage 2
Stage 3
(Stage 4)

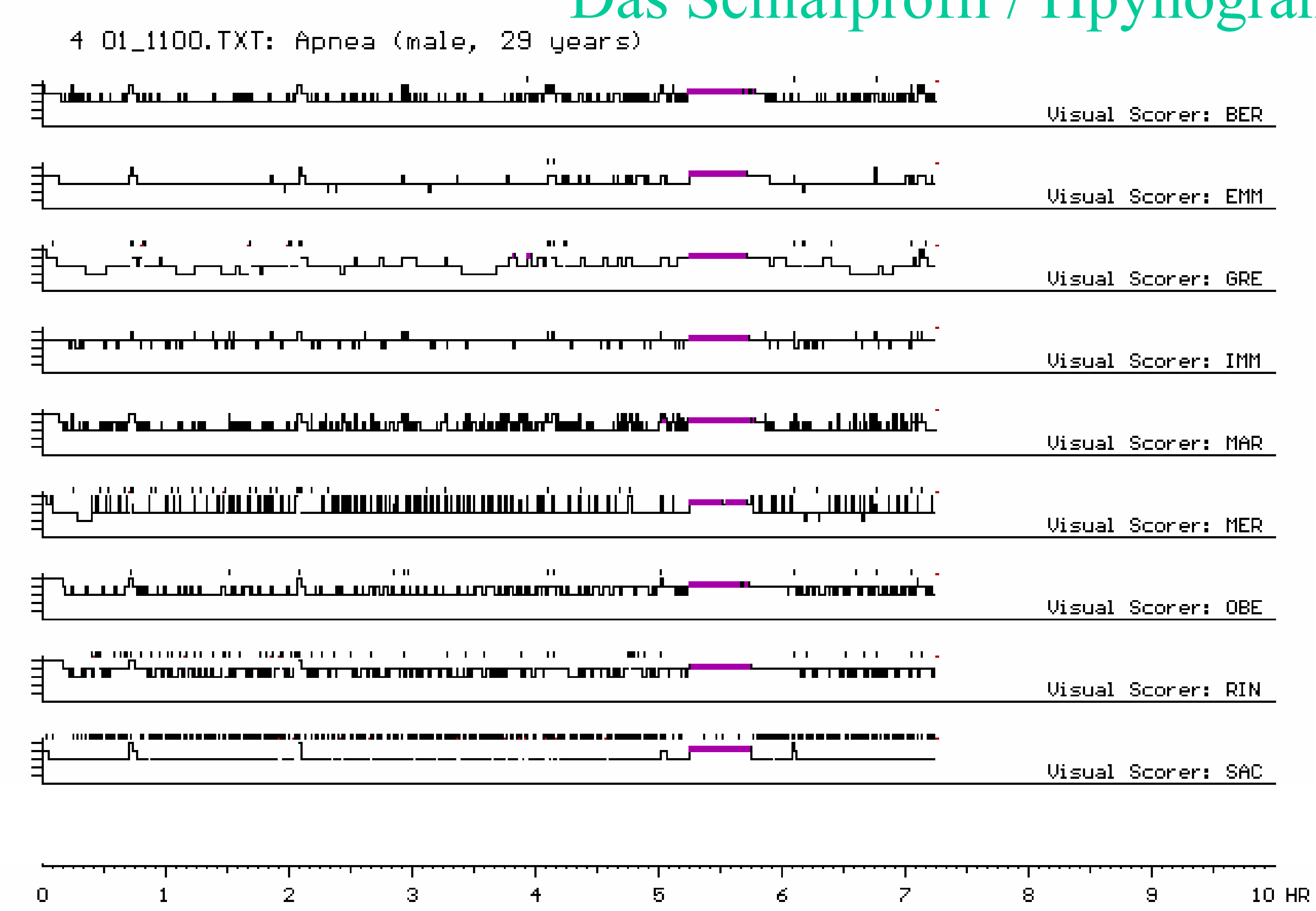
Stage REM

(Stage „Movement Time“)

Neuester Standard
nach AASM

*(alter Standard nach
„Rechtschaffen & Kales“)*

Das Schlafprofil / Hpynogramm



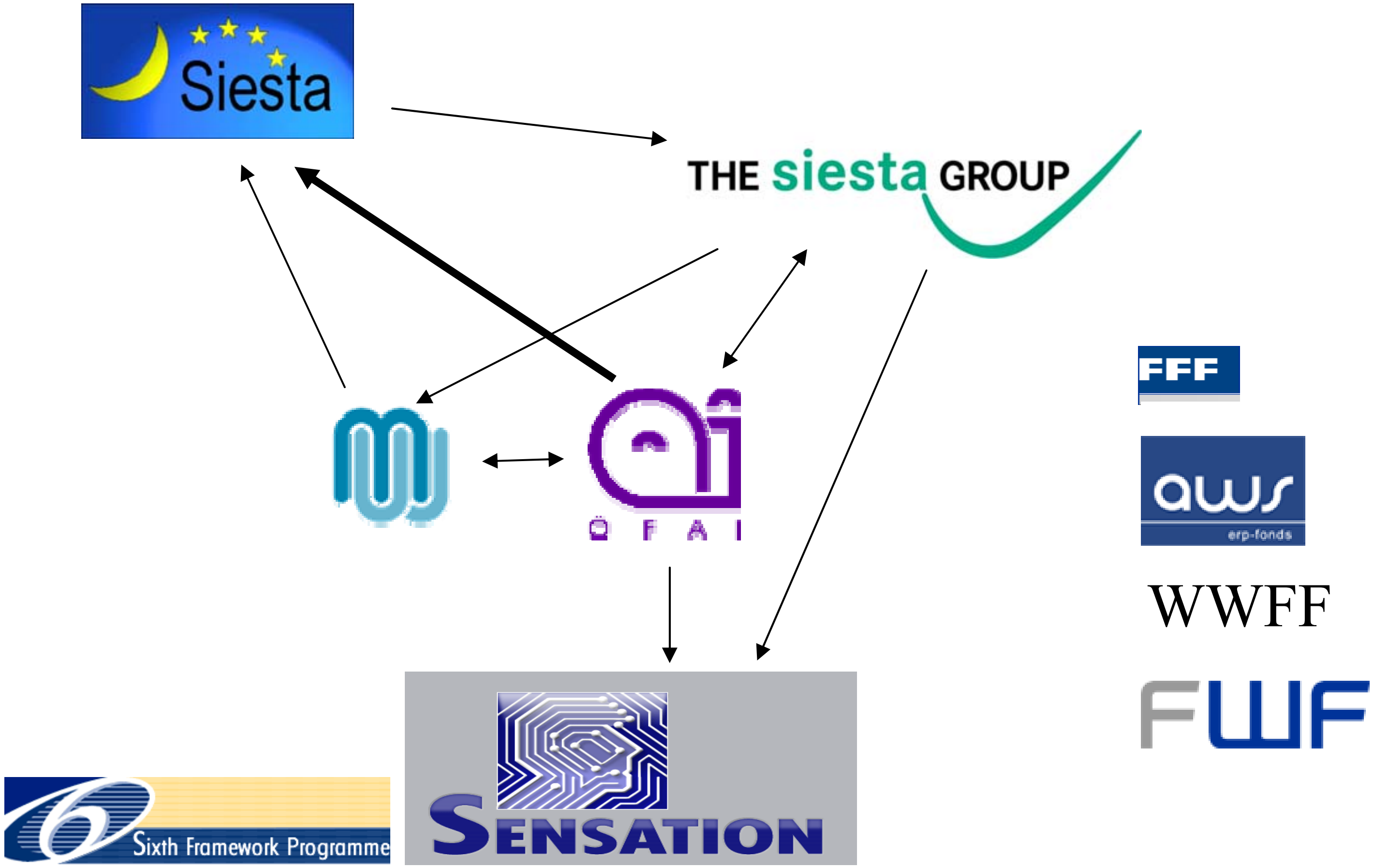
Penzel et al.: Reliabilität der visuellen Schlafauswertung nach Rechtschaffen und Kales von acht Aufzeichnungen durch neun Schlaflabore. Somnologie 7 (2): 49-58, 2003.

Probleme der Schlafauswertung

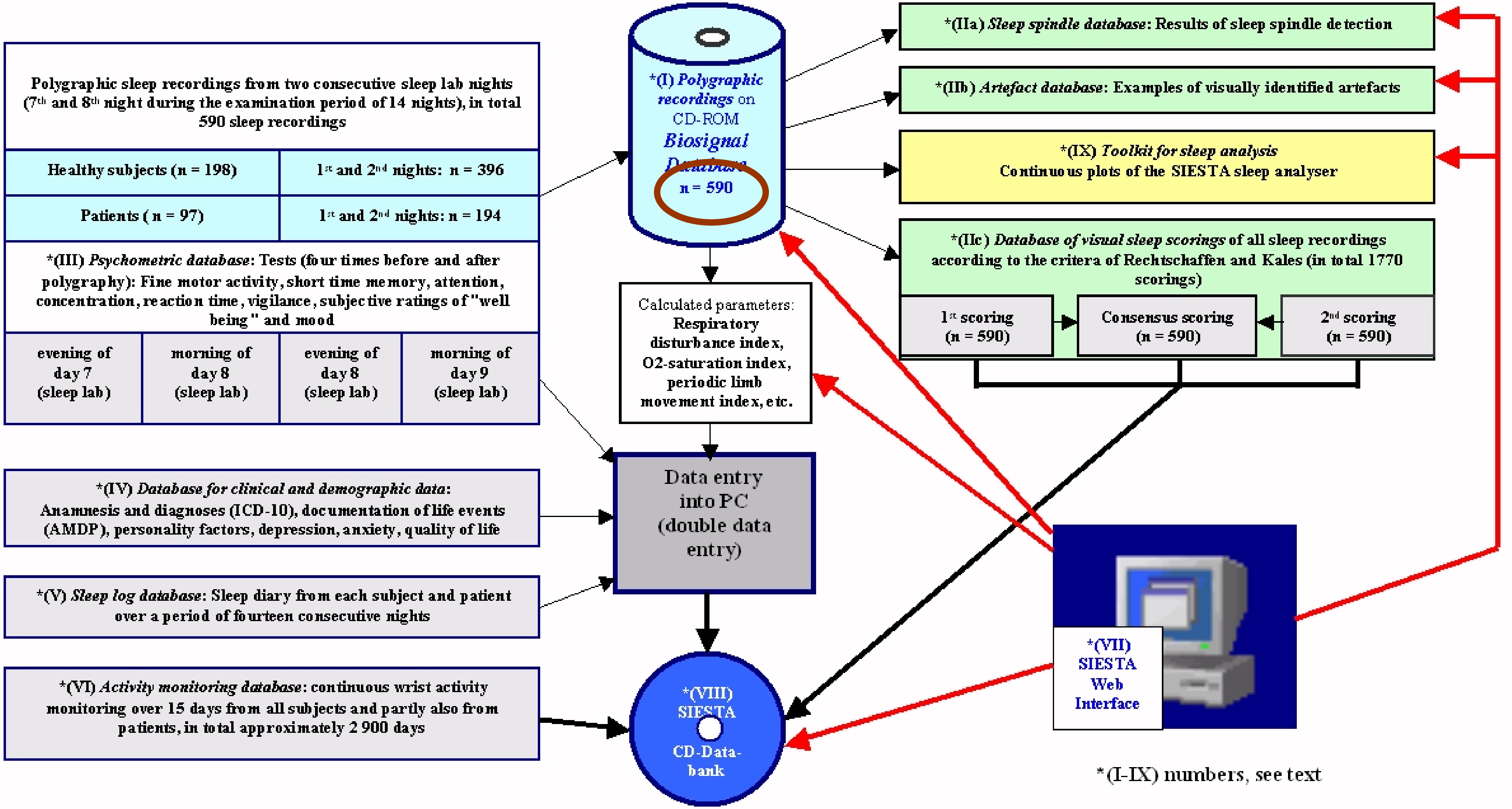
- Hohe Inter-Rater Variabilität
- Subjektive Komponente (trotz quantitativ definierter Kriterien)
- Zeitaufwändiger Prozess
- Geschultes Personal notwendig

→ Valide (verläßliche) und reliable (robuste) automatische Auswertung gefragt

Ein anwendungsorientiertes Projekt



Das SIESTA Projekt: Datenbank



Klösch et al. IEEE ENGINEERING IN MEDICINE AND BIOLOGY, 2001

Die SIESTA-Datenbank

189 healthy controls and 97 patients with sleep disorders

278.086 min polysomnography (~ 480 min per subject)

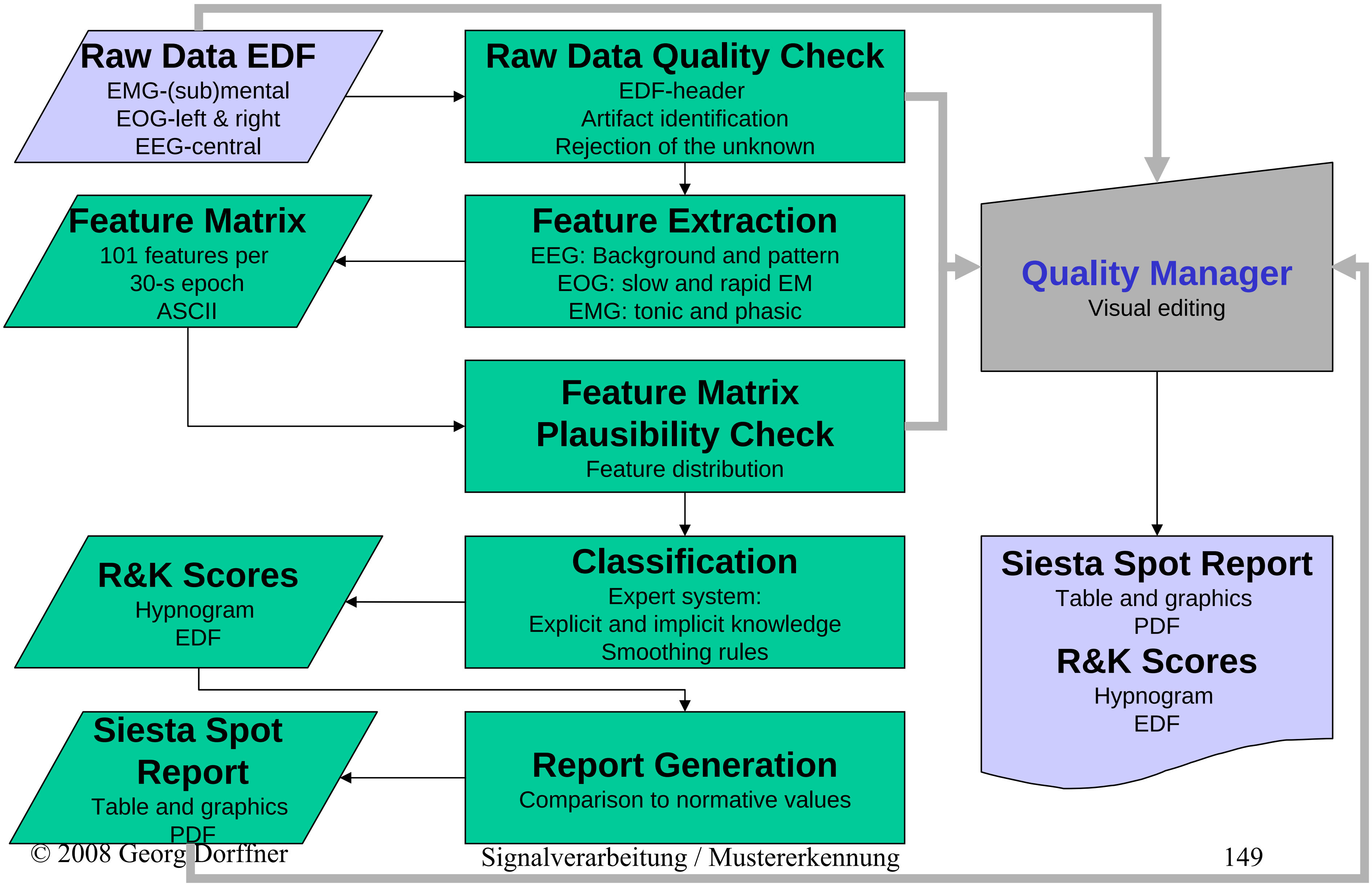
6 stages according to the rules of R&K
(Wake, S1, S2, S3, S4, REM, MT)

30 sleep experts from 8 European sleep labs

"Gold standard" for development and validation of automatic sleep classification system

556.172 30-s epochs visually classified by 3 scorer

Siesta Somnolyzer 24x7

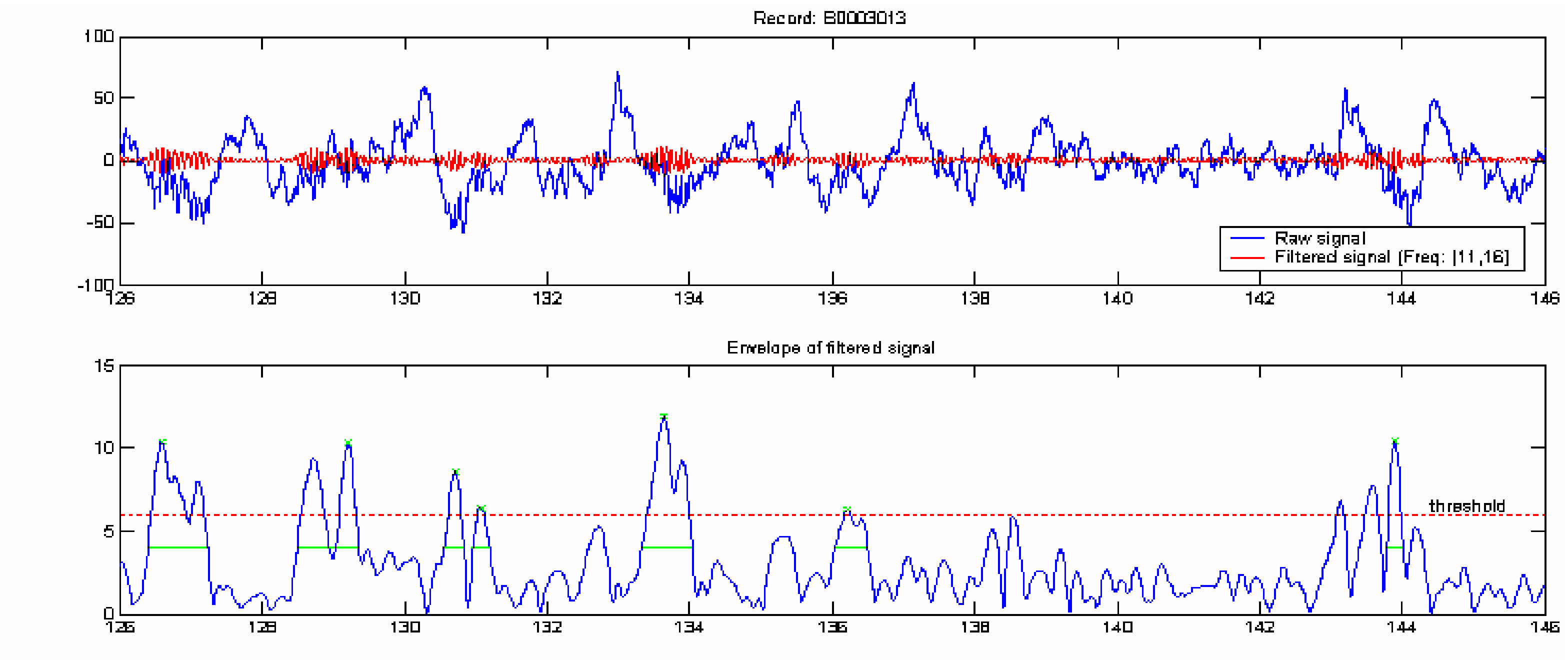


Methoden zur Mustererkennung

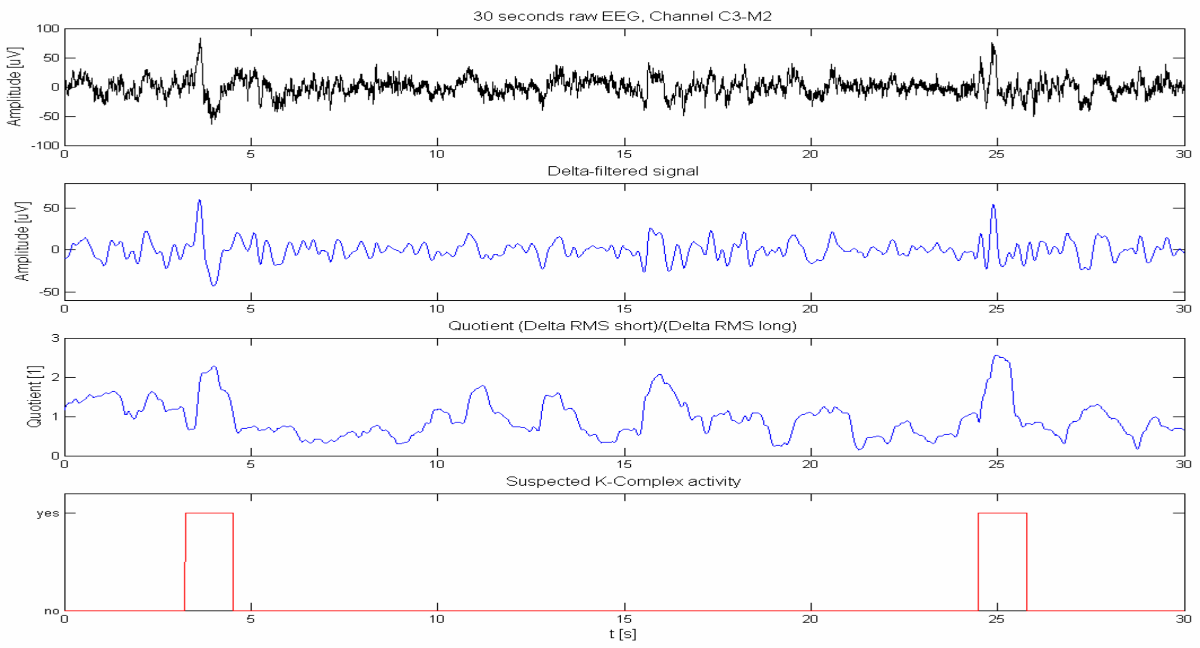
Pattern	Method
Artifact	Minimization: Digital filters, filter smoothers based on autoregressive models[1], adaptive noise canceler with varying weights[2], independent component analysis (ICA)[3]
Artifact	Identification: Voltage threshold (overflow check)[4], discriminant analysis[5], adaptive thresholds (moving median)[6], unsupervised network (NeoART)[7], distance rejection[7], uncertainty rejection[7], automatic relevance determination[8], probabilistic graphical methods[9]
Delta waves	Period-amplitude anaylsis[10], Spectral analysis, Digital band-pass filter
Sleep spindles	Digital filters[11], Neural networks[12], matched filtering[13], wavelets[14]
K-complexes	Neural networks[15], matched filtering[13], wavelets[14], model based detector[16]
Vertex sharp wave	Model based detector[16]
Alpha waves	Period-amplitude anaylsis[10], Spectral analysis, Digital band-pass filter
Eye blinks	Decision process based on amplitude and slopes[17]
Eye movements	Matched filtering techique[18], Rapidly adapting neuronal fuzzy system[19], Discrete wavelet transform[20], Period-amplitude anaylsis[21]
Tonic EMG	Trimmed root-mean square amplitude
Phasic EMG	Maximal peak-to-peak amplitude

[1]Larsen and Prinz (1991); [2]Sahul et al. (1995); [3]Roberts (1998); [4]Schlögl et al. (1999);
[5]Anderer et al. (1999); [6]Brunner et al. (1996); [7]Schaltenbrandt et al. (1993, 1996); [8]MacKay (1995);
[9]Jensen (1996); [10] Ktonas and Gosalia (1981); [11]Schimicek et al. (1994); [12]Huuponen et al. (2000);
[13]Jobert et al. (1992); [14]Jobert et al. (1994); [15]Strungaru and Popescu (1998); [16]Da Rosa et al. (1991);
[17]Anderer (2002); [18]Hatzilabrou et al. (1994); [19]Wallner (1996); [20]Tsuji et al. (2000); [21]Tan et al. (2001)

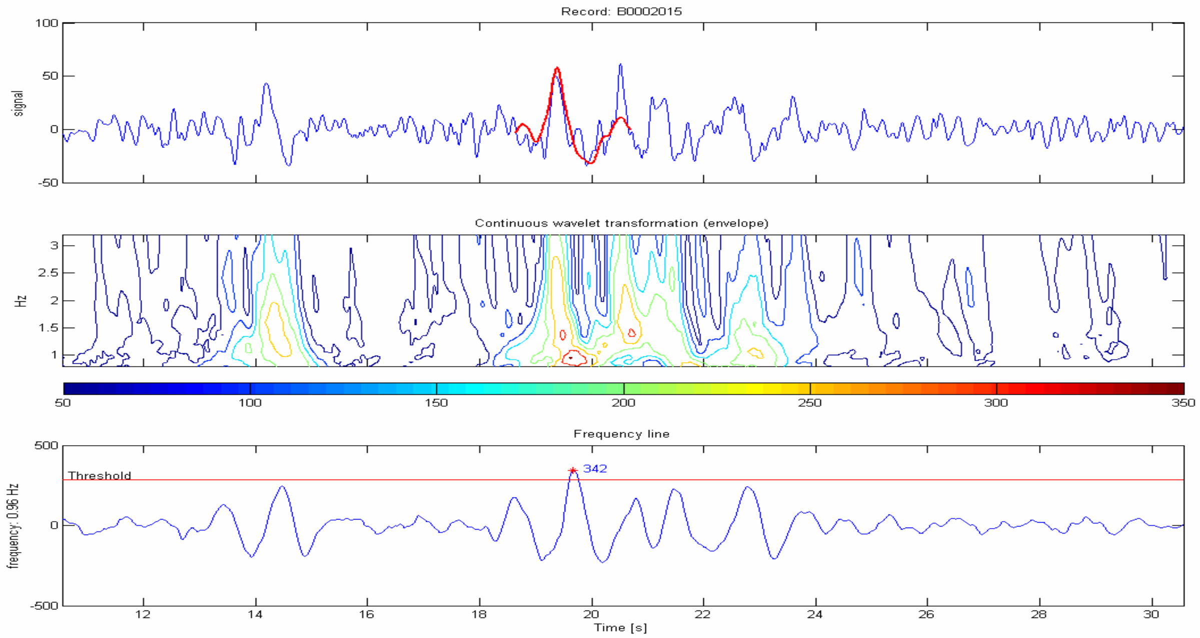
Automatic sleep spindle detection
Step 1 (Step 2: LDA)



Automatic K-complex detection
Step 1



Automatic K-complex detection
Step 2



Results of the validation

Sleep spindles:

- Validation:

  Sensitivity: 86%   Specificity: 85%

- Per experts:

  Sensitivity: 77-92%   Specificity : 76-90%

- Per recording lab:

  Sensitivity: 74-94%   Specificity: 83-88%

Results of the validation

K-complexes:

- Validation:

  Sensitivity: 88% Specificity: 87%

- Per experts:

  Sensitivity: 78-94% Specificity : 80-93%

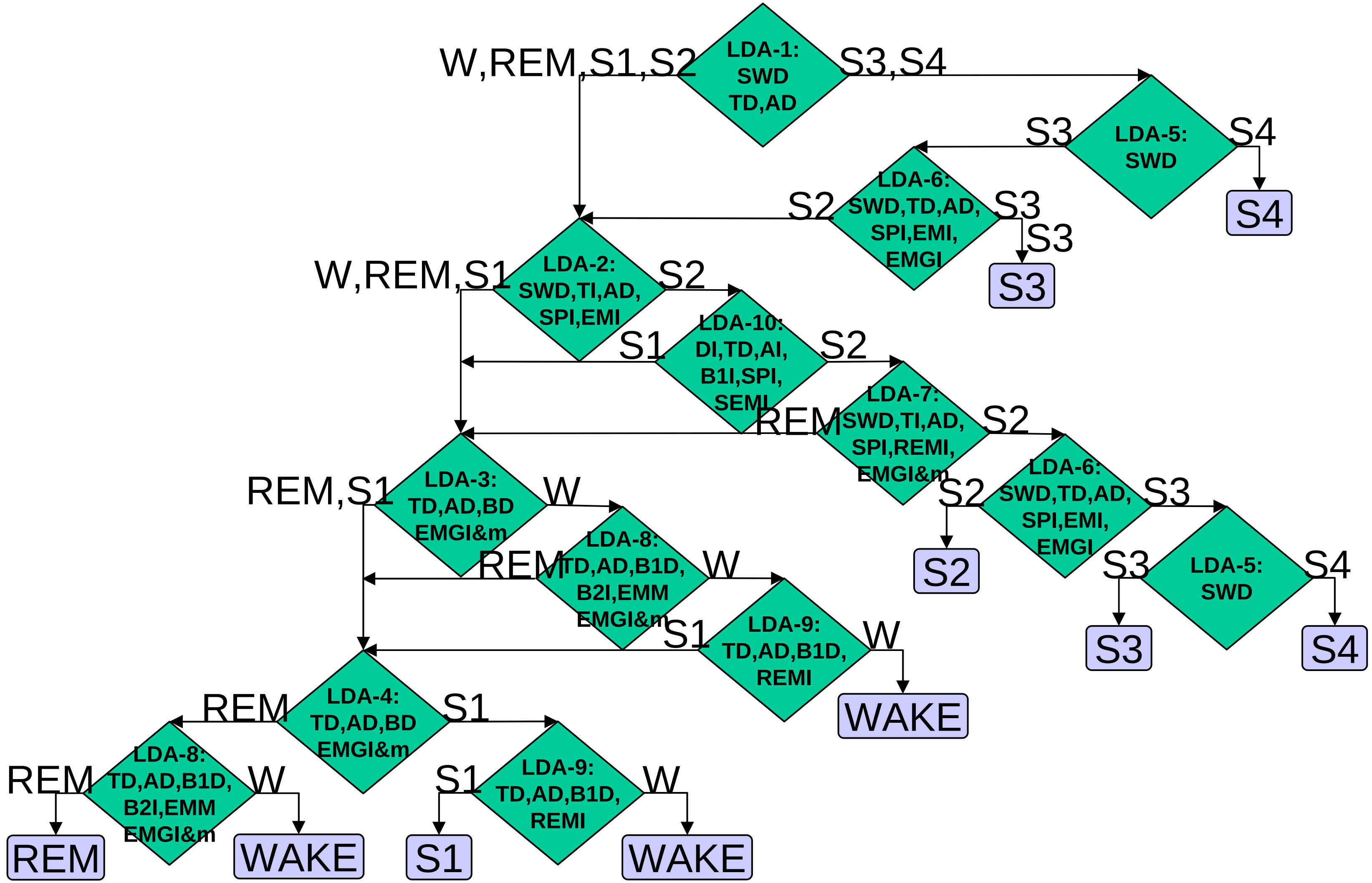
- Per recording lab:

  Sensitivity: 80-92% Specificity : 73-93%

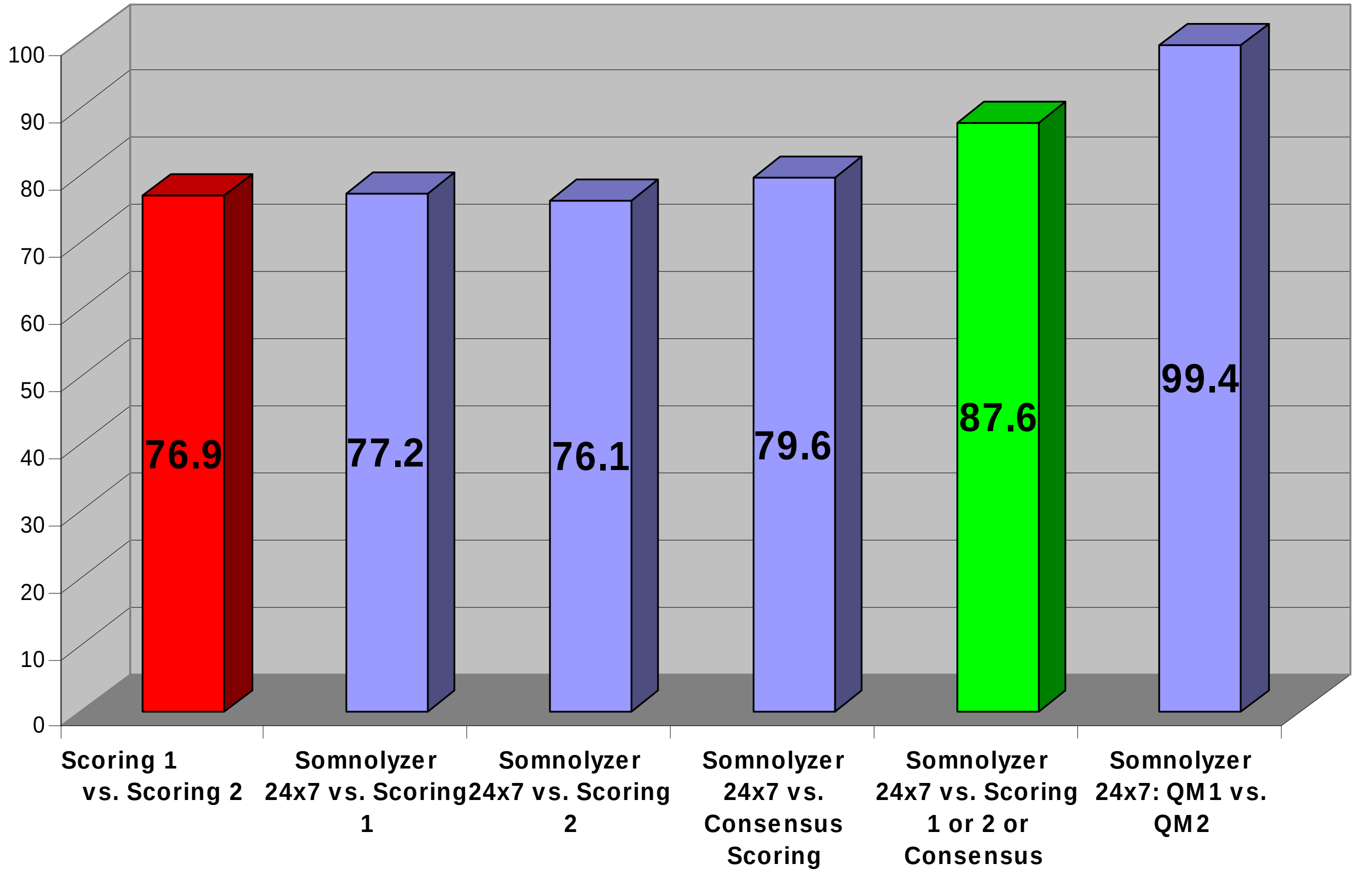
Expert System

- (1) Explicit knowledge (e.g. slow waves speak for S3 or S4)
- (2) Implicit knowledge (e.g. S4 usually does not follow S1 directly)
- (3) Smoothing rules (start and end of stage REM, 3-min rule for S2)

Scoring durch Expertensystem



Performanz
(Validierungsset, 285 Aufnahmen, 270.100 Epochen)



Anderer et al., Neuropsychobiology 2005;51(3):115-33

Ein detaillierter Vergleich

Visual Scorer 1 vs. Visual Scorer 2

	W	1	2	3	4	REM
W	**85.5**	10.9	2.9	0.0	0.0	0.6
1	16.7	**47.8**	27.9	0.1	0.0	7.5
2	0.9	7.4	**84.7**	4.8	0.5	1.7
3	0.1	0.2	35.2	**45.2**	19.2	0.0
4	0.0	0.1	7.7	27.4	**64.8**	0.0
REM	2.4	7.5	5.2	0.0	0.0	**84.9**

SOMNOLYZER 24x7 vs. Visual Consensus Scorer

	W	1	2	3	4	REM
W	**85.6**	10.8	2.5	0.3	0.1	0.7
1	13.5	**59.3**	19.3	0.4	0.1	7.4
2	1.2	8.4	**82.5**	5.7	0.6	1.7
3	0.1	0.0	22.8	**55.0**	22.1	0.0
4	0.1	0.0	1.3	21.3	**77.3**	0.0
REM	2.5	7.6	5.1	0.1	0.0	**84.6**

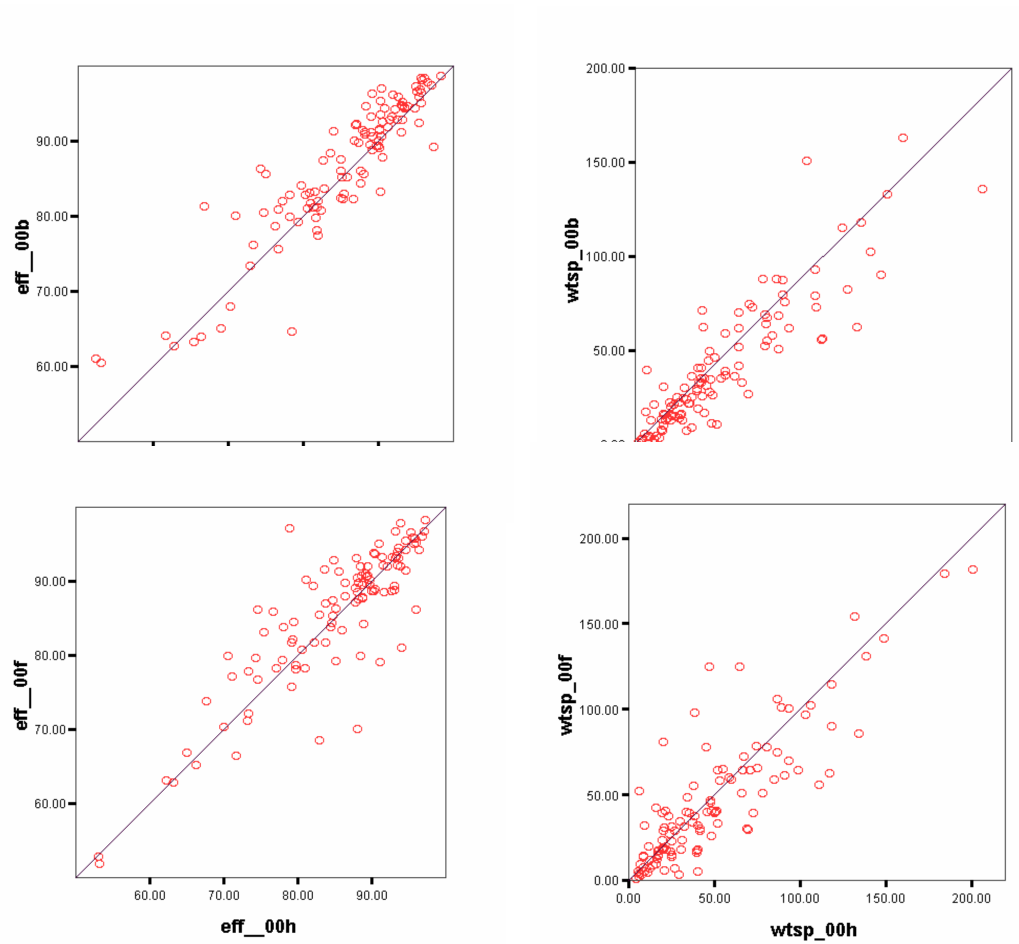
Table 10. Overall agreement (%) between Somnolyzer 24 × 7 and human expert consensus scoring as compared with the overall agreement between human expert scoring 1 versus scoring 2 for different subgroups of the Siesta validation database

	Controls (n = 186)	Controls <40 years (n = 57)	Controls 40–59 years (n = 63)	Controls >60 years (n = 66)	Apnea patients (n = 50)	Nonorganic insomnia (n = 27)	Parkinson disease (n = 14)
Expert scoring 1 vs. scoring 2	77.6	81.6	78.0	73.9	73.7	80.8	71.7
Somnolyzer 24 × 7 vs. consensus scoring	80.4	84.2	81.9	75.8	75.6	85.6	73.1

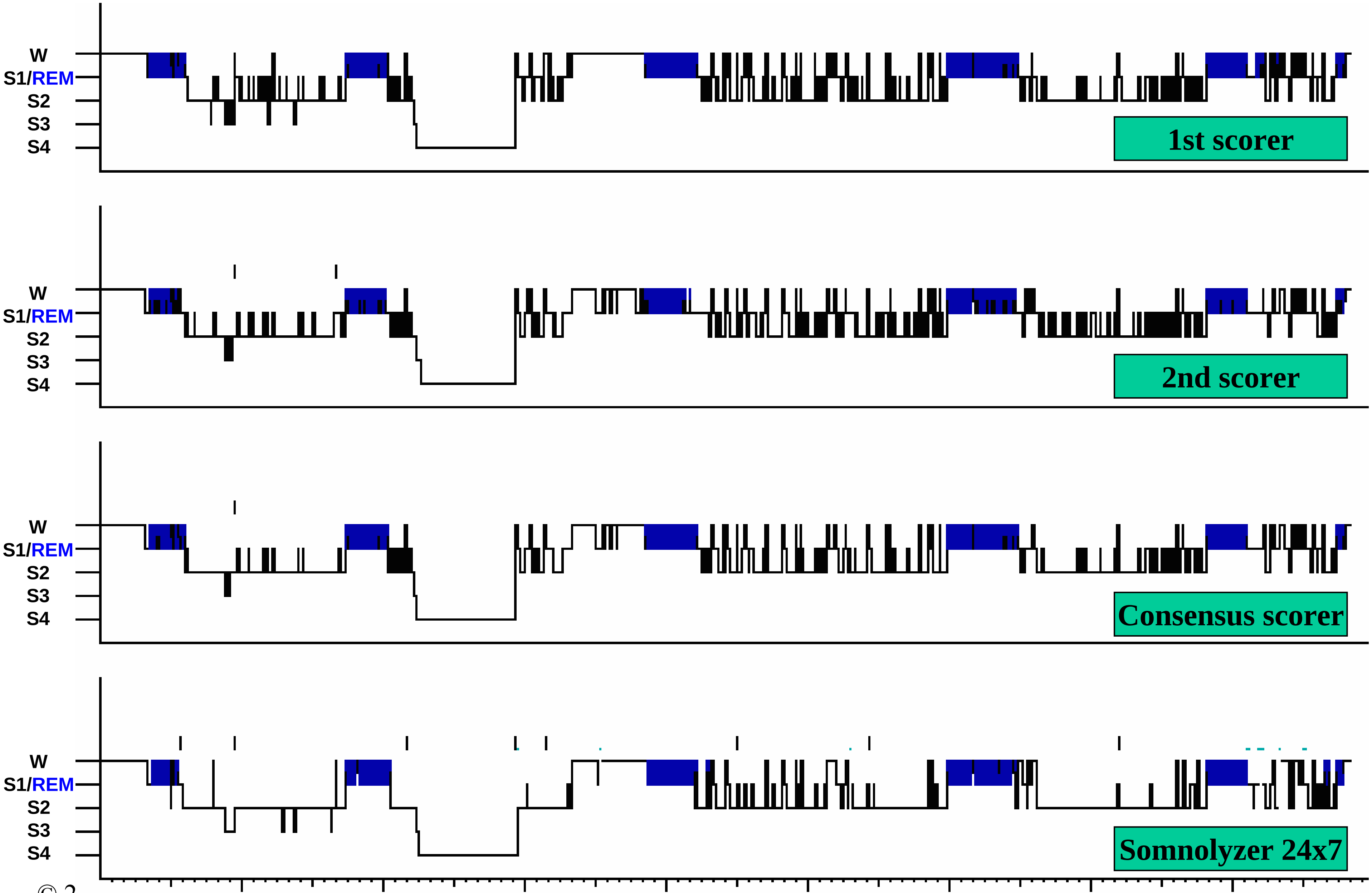
Performanz anhand Schlafparameter

Somnolyzer 24x7
vs.
Consensus Scoring:

Scorer 1
vs.
Scorer 2:

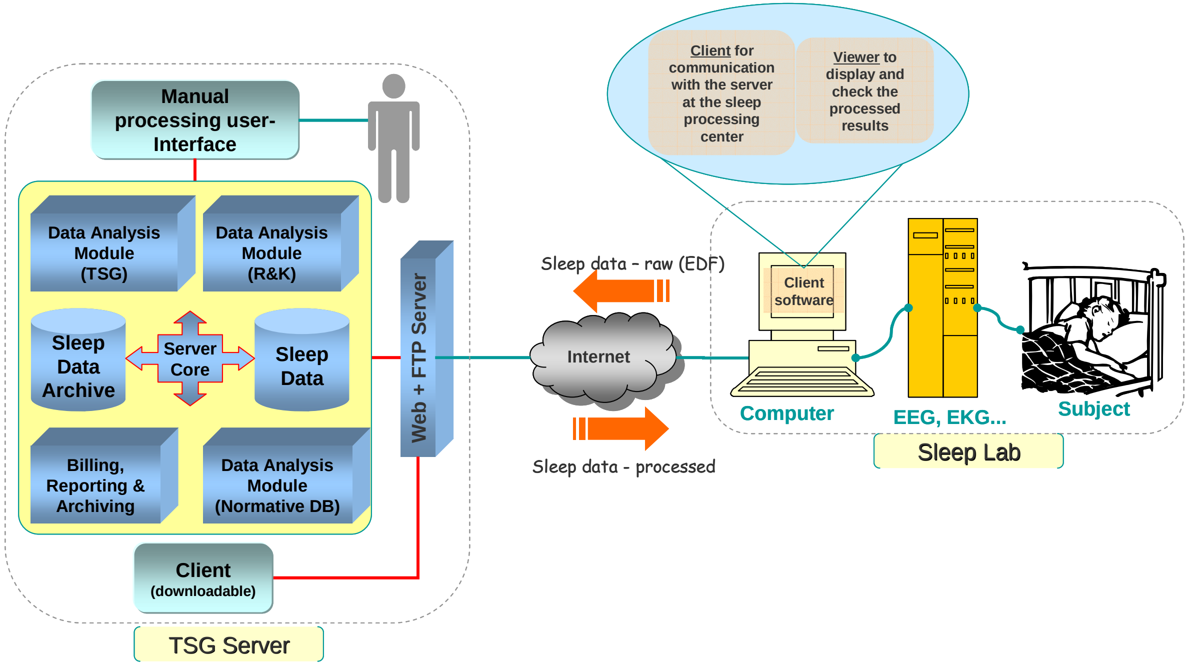


MA02702: Apnea patient (AHI: 82), 38 years, male, Second night



Einsatz in der Praxis

- Server-basierte Lösung („e-health“)

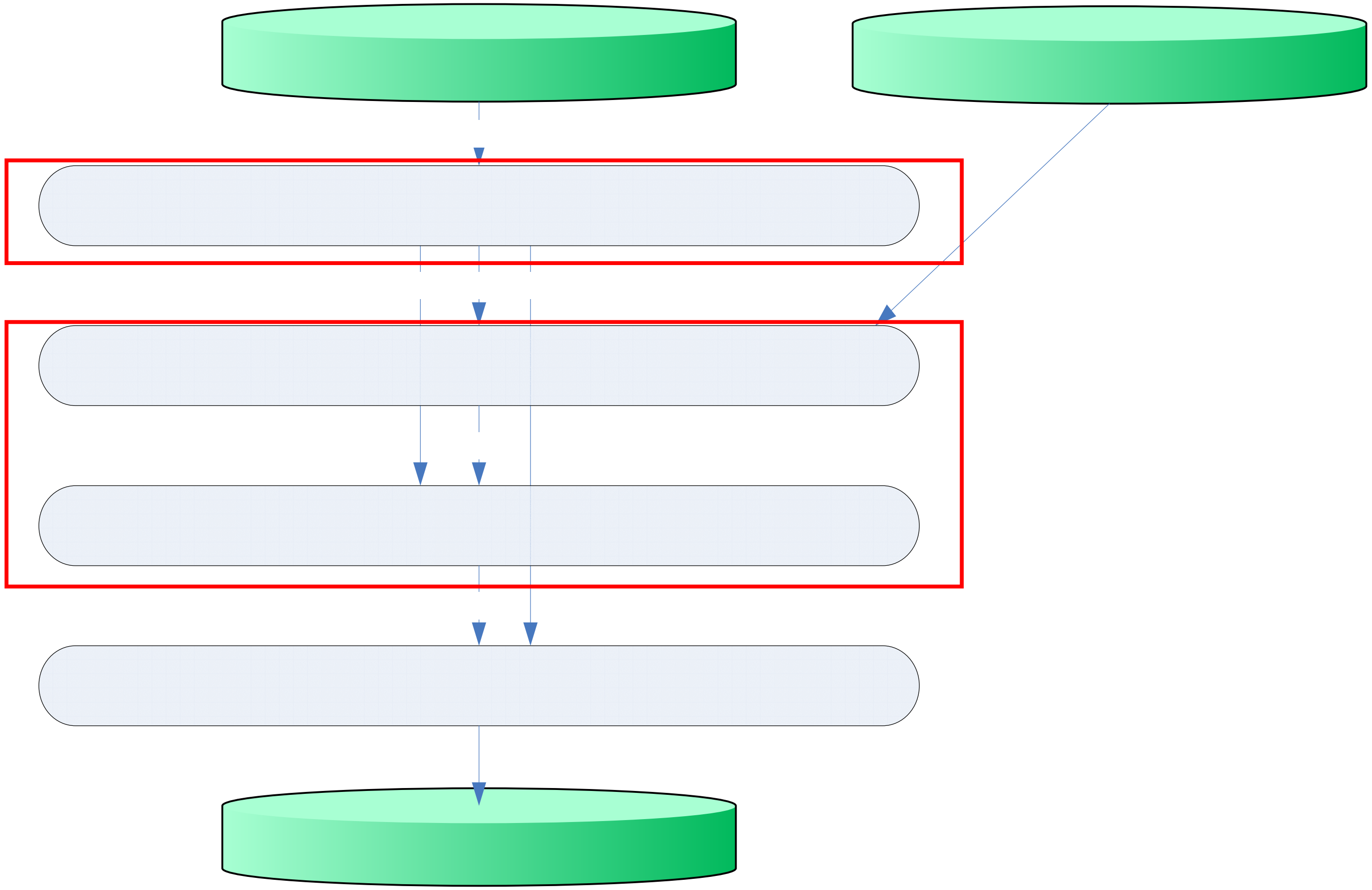


Weitere Forschungsrichtung

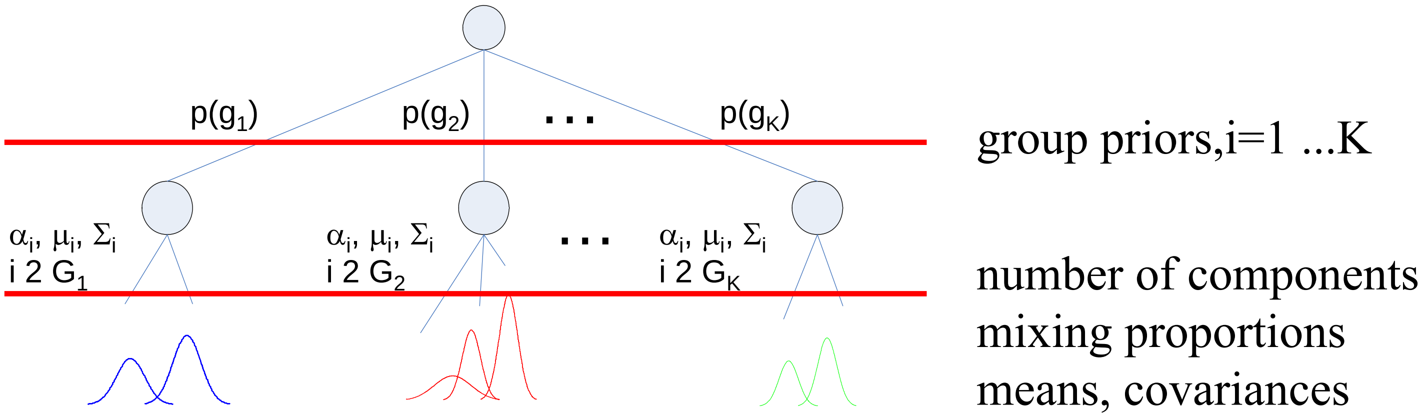
- Nachteil der Schlafstadien:
  - Sehr grobe Auflösung
  - Keine „Mikrostruktur des Schlafs“
  - Einteilung in Stadien relativ willkürlich
  - Schlechte Entsprechung mit subjektiven Parametern

→ Kontinuierliche Schlafmodellierung

Kontinuierliches Schlafmodell



Hierarchisches GMM

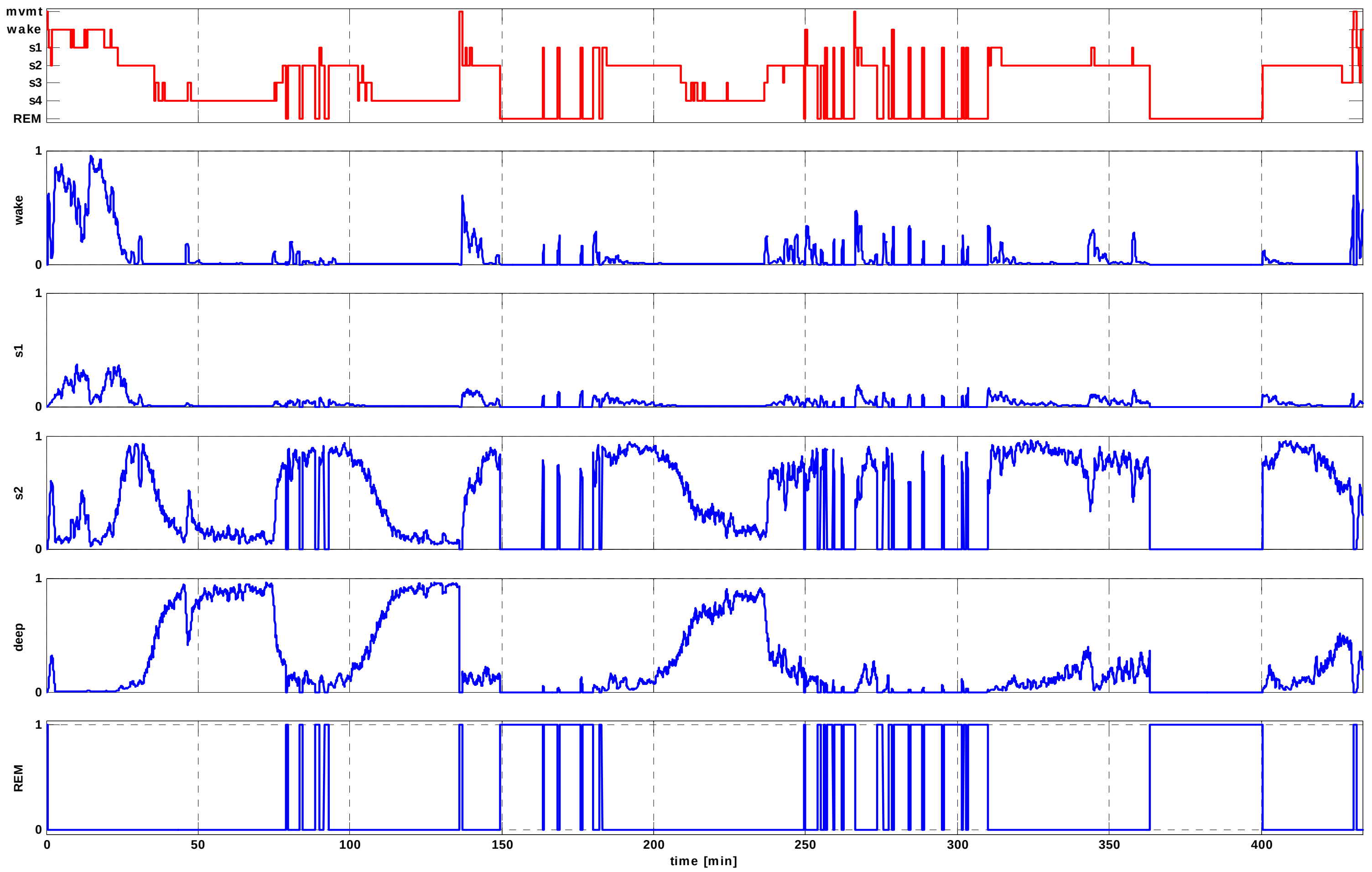


Step1: train mixtures of individual classes, set group priors

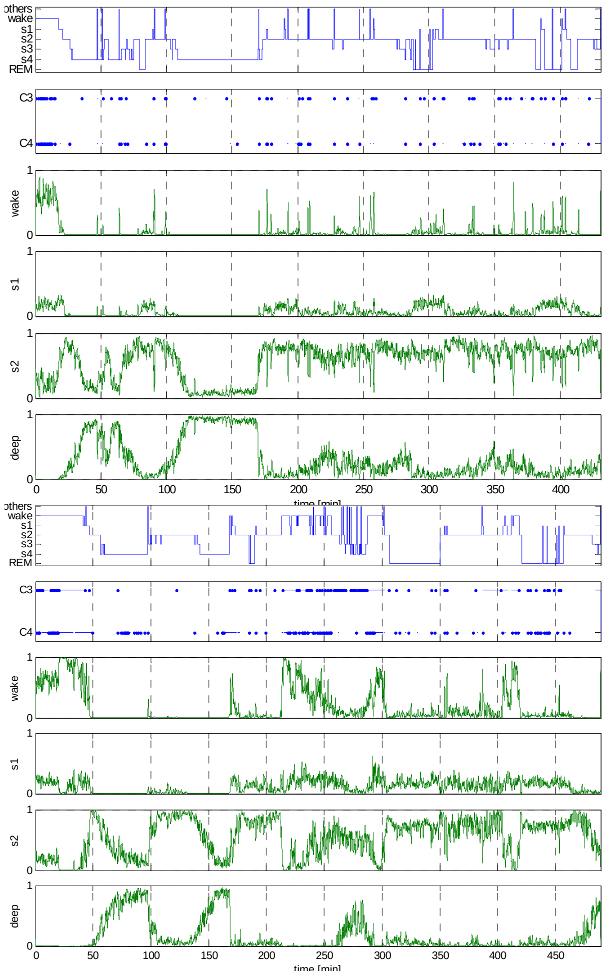
Step2: unsupervised (semi-supervised) *reshuffling*, keep structure

Output: probabilities to be in each stage

Kontinuierliches Schlafprofil



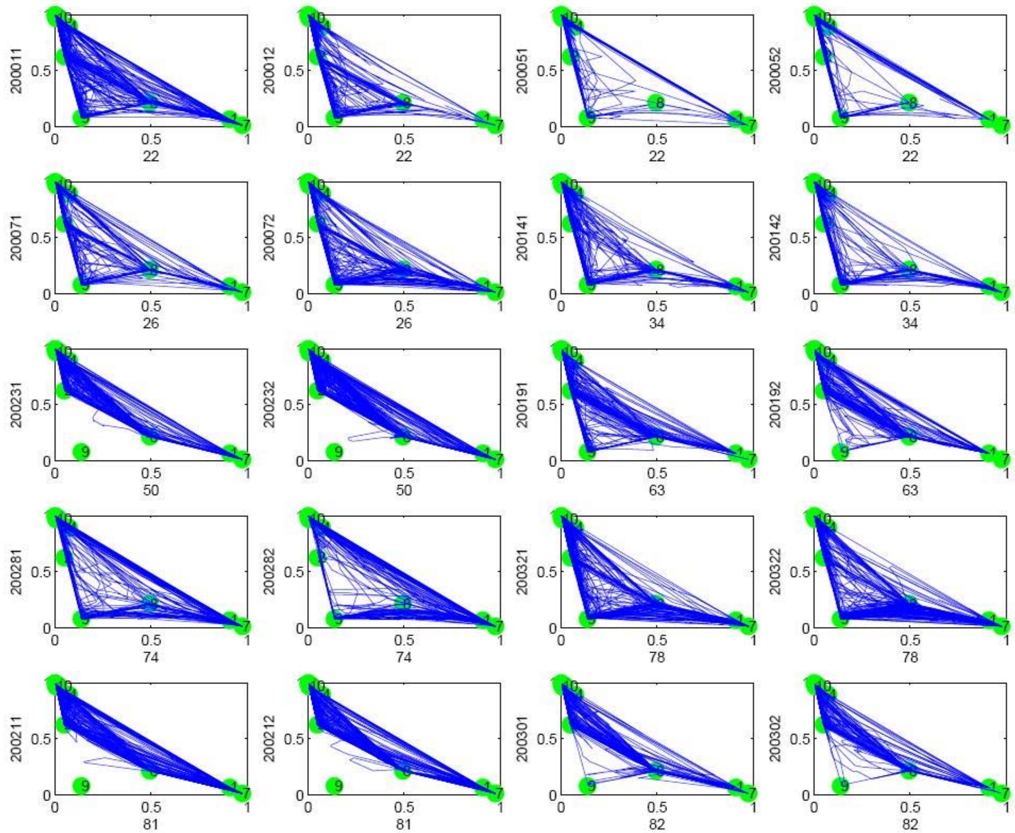
Korrelationen mit subjektiven Parametern



c_eff	-0.538	-0.303	rk_eff	-0.542	-0.427
c_wake_tsp	0.527	0.255	rk_wake_tsp	0.517	0.411
c_rAUC_wake	*0.529*	0.353			
c_s1_tst	0.328	0.144	rk_s1_tst	0.332	0.375
c_rAUC1_s1	*0.336*	0.275			
c_s2	-0.303	-0.103	rk_s2	-0.325	-0.205
c_rAUC_s2	*-0.311*	-0.052			
			rk_s4	-0.245	-0.354
c_rAUC2_deep	*-0.401*	-0.220			
c_rAUC1_deep	*-0.396*	-0.121			
c_rAUC_deep	*-0.289*	-0.198			
c_fw	0.300	0.208	rk_fw	0.213	0.351

Correlations with the night differences subjective Sleep Quality Index

Schlafmuster als „Fingerprint“?



Zusammenfassung

- Methoden der Signalverarbeitung bewähren sich in der klinischen Praxis
- Automatisierte Auswertung als Unterstützung des Arztes
- Qualitätskontrolle notwendig
- Signalverarbeitung kann Zugänge zur Information im Signal bieten, die dem menschlichen Auge verborgen bleibt