SENSORS in the field of SLEEP

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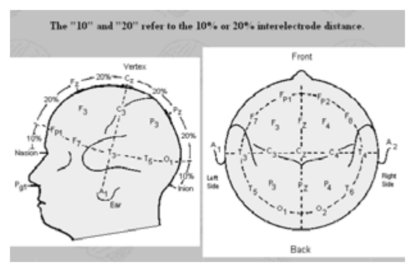
PSG in History

- 1875: Discovery of brain-wave activity
- 1930: Description of differences between the waking and sleeping states
- 1937: A correlation between apparent behavioural sleep and EEG documentation of sleep.
- 1947: Recommendation to further study sites of recording brain activity.
- 1953: Inclusion of electro-oculography (EOG)
- 1957: Discovery of rapid eye movements during sleep with episodes of completely activated EEG

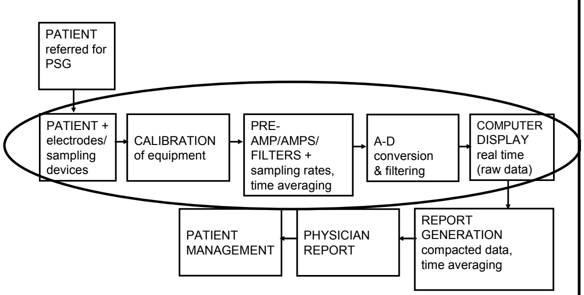
PSG in History continued

- 1957: Eye movements related to dream activity
- 1958: International 10-20 (%) system of electrode placement was developed (23 electrode sites)
- 1959: EMG muscle tone suppressed in REM
- 1968: Standardized terminology, techniques and scoring for sleep stages (R &K) developed
- 1974: Term polysomnography (PSG) was proposed
- 1978: Routine PSG consisted of EEG, EOG, EMG (mentalis, submentalis), EMG (tibialis) ECG, oxygen saturation, nasal airflow and rib cage and abdominal respiratory effort

10-20 System



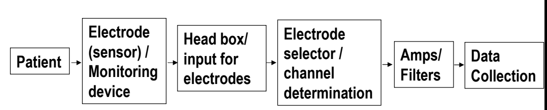
Remember



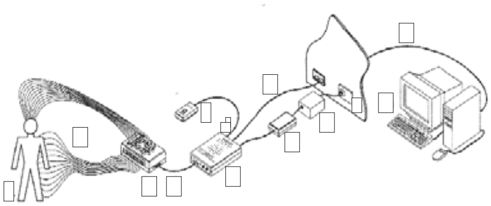
Investigating this chain of events – Scientist role

Measurement of physiological signals in sleep.

- Electrophysiological signals begin at the patient and end at the recording equipment.



Circuit layout



The PSG (Polysomnogram)

- **The primary function of the PSG is to allow us to record and monitor bioelectric activity of the body.**
- **The signals from the cortex and from other sites are extremely small voltages (some micro volts).**

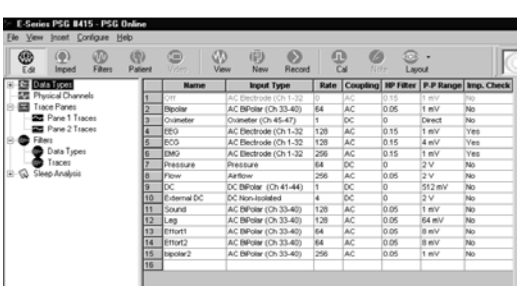
The PSG continued

- **In addition the PSG allows us to accentuate or optimize a signal by filtering out data that are not relevant to the signal of interest. The frequency ranges required is determined by assessing the recorded frequencies and determining the frequencies of extraneous potentials we wish to eliminate.**
- **We need to amplify and record the differences in potentials between two inputs and simultaneously compare them to a reference.**

The PSG continued

- **For example in a limb channel we wish to record high frequency muscle potentials but have no interest (for that channel) in low frequency potentials like slow respiratory movements.**
- **We set the filters such that the high frequency potentials “pass through” and the lower frequency extraneous potentials are “filtered out”.**
- **We then accentuate the selected signal (limb muscle bursts) by selecting an appropriate sensitivity to display the signal in a meaningful, readable amplitude.**

Data Types



	Name	Input Type	Rate	Coupling	HP Filter	P-P Range	Imp. Check
1	Off	AC Electrode (Ch 1-32	0	AC	0.15	1 mV	No
2	Bipolar	AC BiPolar (Ch 33-40)	64	AC	0.05	1 mV	No
3	Oximeter	Oximeter (Ch 45-47)	1	DC	0	Direct	No
4	EEG	AC Electrode (Ch 1-32	128	AC	0.15	1 mV	Yes
5	ECG	AC Electrode (Ch 1-32	128	AC	0.15	4 mV	Yes
6	EMG	AC Electrode (Ch 1-32	256	AC	0.15	1 mV	Yes
7	Pressure	Pressure	64	DC	0	2 V	No
8	Flow	Airflow	256	AC	0.05	2 V	No
9	DC	DC BiPolar (Ch 41-44)	1	DC	0	512 mV	No
10	External DC	DC Non-Isolated	4	DC	0	2 V	No
11	Sound	AC BiPolar (Ch 33-40)	128	AC	0.05	1 mV	No
12	Leg	AC BiPolar (Ch 33-40)	128	AC	0.05	64 mV	No
13	Effort1	AC BiPolar (Ch 33-40)	64	AC	0.05	8 mV	No
14	Effort2	AC BiPolar (Ch 33-40)	64	AC	0.05	8 mV	No
15	bipolar2	AC BiPolar (Ch 33-40)	256	AC	0.05	1 mV	No
16							

Sampling rates quite high in relation to frequencies BUT better

E Series (COMPUMEDICS)

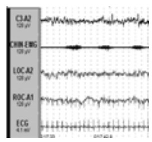
- **64 channels capability**
  - **presently use 17 channels**
    - **EEG x2**
    - **EOG x2**
    - **chin EMG**
    - **ECG**
    - **Position**
    - **leg EMG**
    - **Thermister**
    - **Nasal Pressure x2**
    - **Thoracic and Abdomen**
    - **dB Sound**
    - **SaO2**
    - **tcCO2**
    - **CPAP**
      - **+ digital video**

Types of Sensors used in Sleep

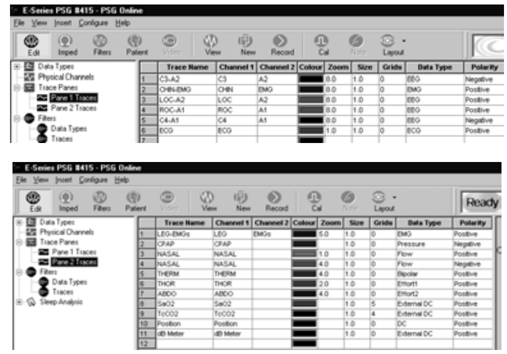
- Changes in electrical activity of the body
  - Electrode sensors measuring voltage
    - ECG Heart rate and rhythm
    - EMG Muscle tone and movement (chin and leg)
    - EEG Brain's electrical signal (1000's neurons)
    - EOG Eye movements

    - Use 10mm Gold cup electrodes or in some instances ECG dots
    - Referential amplifiers used.
    - Impedance < 10KΩ

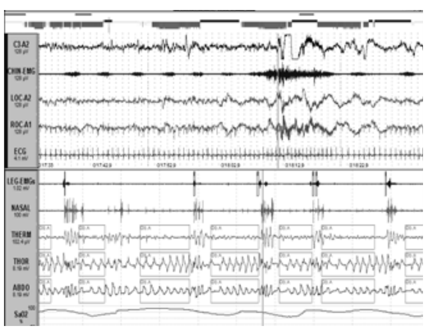
- **EEG, EOG, ECG LP= 30 HP= 0.3**
- **Leg and chin EMG LP= 100 HP= 20**



Trace Panes

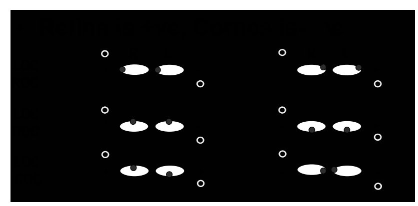


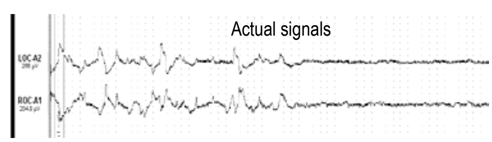
Sensors, amplifiers and filters help us to obtain this recording



Which helps to diagnose patients with sleep disorders

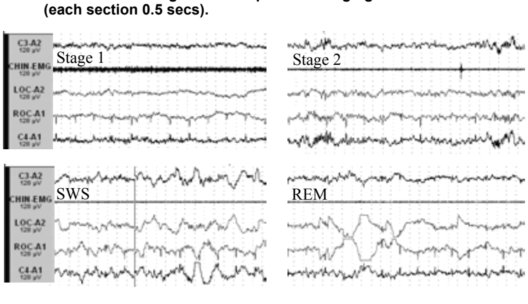
EOG (Electrooculogram)

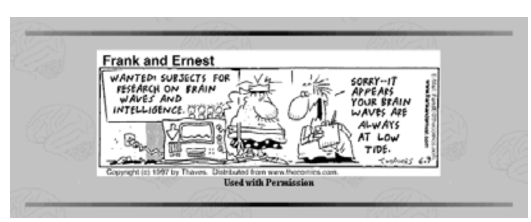




EEG (Electroencephalogram)

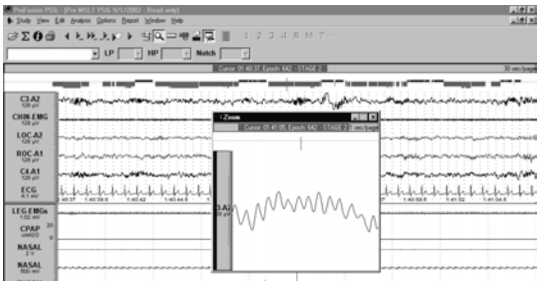
- **These sensors help us to measure what stage of sleep the patient is in.**
- **There are four stages with frequencies ranging from 0.5 to 14 Hz. (each section 0.5 secs).**





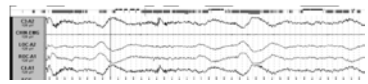
Low voltage, mixed frequency present when DROWSY!

Close up of the frequency of the EEG signal.

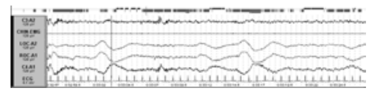


Artefact improved on EEG

- LP 30 HP 0.3

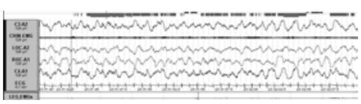


- LP 30 HP 1

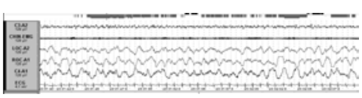


Signal quality lost!

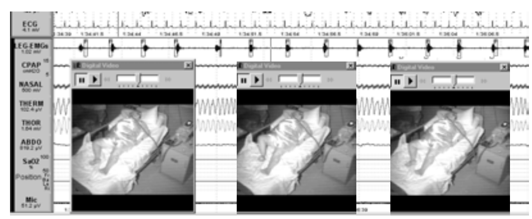
- LP 30 HP 0.3



- LP 30 HP 10

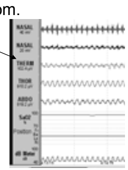


LEGS and VIDEO



Sleep Sensors continued.

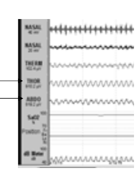
- Temperature sensors
  - Thermocouples/Thermistors
    - Measure airflow (Exp Temp↑ Insp Temp↓)
    - The thermistor sensor changes temperature (breath out warm air(37°C) and breath in cooler air (21°C))
    - The temperature changes the resistance of the circuit.
    - The change in resistance then affects the voltage output which we obtain out signal from.
    - Measure nasal and oral sites.



●THERM LP= 30 HP= 0.3

Sleep Sensors continued.

- Movement sensors
  - Piezo crystal sensors
    - Chest and Abdomen movements measured.
      - » As the sensor is deformed or stretched a voltage of either negative or positive is produced.
      - » Exp: chest moves down, Insp chest moves up)

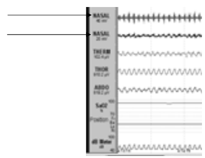


●THOR LP= 5 HP= 0.05

●ABDO LP= 5 HP= 0.05

Sleep Sensors continued.

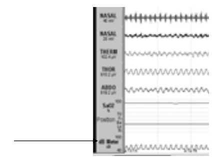
- Pressure sensors
  - Differential / Direct pressure sensors
    - Nasal pressure
      - » membrane flexes as pressure changes
      - » +ve pressure insp and –ve pressure exp



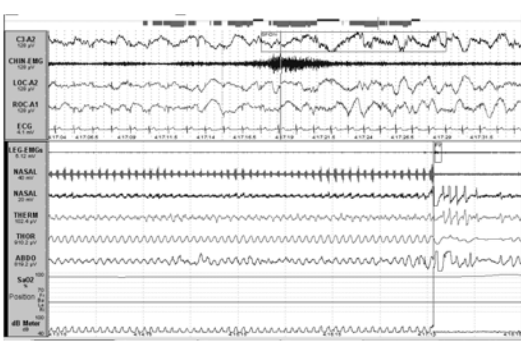
- NASAL (SN) LP= OFF HP= 10
- NASAL (FLOW) LP= 5 HP= 0.05

Sleep Sensors continued.

- Sound meter sensor
  - Snoring (dB)
    - membrane flexes as pressure changes
    - sound pressure
    - logarithmic scale

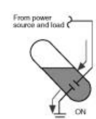


Nasal Pressure and Sound



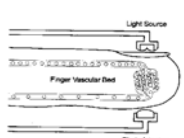
Sleep Sensors continued.

- Position Sensor
  - Mercury switch
    - **Once the mercury flows into one part of the circuit it completes the circuit for charge to flow. Each section produces a different charge. Therefore we know what position**



Sleep Sensors continued.

- Oximeter
  - Measure O_2 levels in the blood
    - Based on the fractional change in light transmission during an arterial pulse at two different wavelengths,.
      - (red and infra red light, 660nm and 890-950nm)
      - Measures the difference between O_2Hb and HHb haemoglobin (each absorbing diff amounts of light)



Sleep Sensors continued.

- tcCO2 and tcO2 (Transcutaneous)
  - A combined electrode:
    - **heating element**
    - **Clark type (O2)**
    - **Severinghaus type (CO2)**
    - **Heat is transferred to the skin from the heating element via the Ag/ Ag Cl electrode to the skin surface. The heating produces local vasodilation and increases permeability of the skin to oxygen and carbon dioxide**

Sleep Sensors continued.

- tcO2
  For the pO2 reading oxygen diffuses to the platinum cathode through the electrodes membrane. A reduction in oxygen occurs as a result of the current generating process.This reduction generates a current which is fed into the pO2 channel and converted to a voltage, digitalized then passed to the micro computer and displayed.

- tcCO2
  The pCO2 measurement is a pH measurement. As CO2 is released from the skin it diffuses into the electrolyte. It reacts with water forming carbonic acid and immediately dissociates by the following equation.
  The changes in H in the electrolyte imply changes in pH.
  As the pH in the electrolyte changes, the voltage between the glass electrode and reference electrode changes. This change is converted to pCO2 by the Henderson Hasselbach equation.
  The signal is then digitalized.

Process

- With all signals you do not just plug the sensor in and display the recording.
- The signal is amplified (Pre Amps/ Amps)
- Then filtered for different types of noises. (Filters)
- Then the signal is displayed on a monitor.
- There are different amplifiers and filters depending on the voltage, frequency and amplitude of the physical signal.

What the sensors look like on the patient

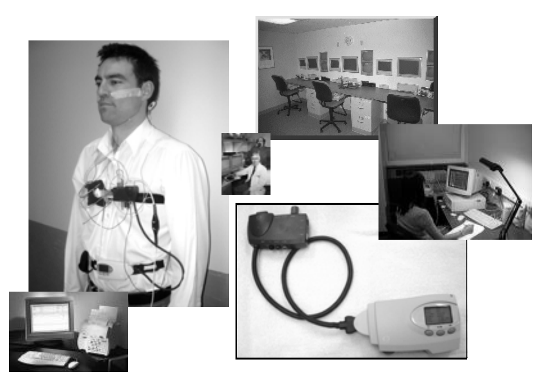
Patient connected with all sensors



Past- Equipment

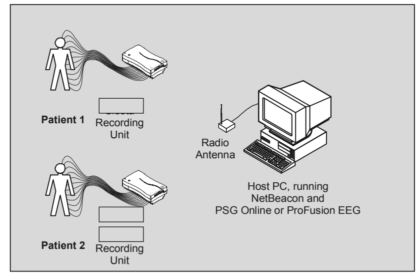
- Old set-up ie bulky, chart recorder, noisy signals, inefficient for storage

Present Equipment we Use



Problems we encounter

- ECG interference
- Respiratory
- Perspiration
- Body motion
- Defective electrodes
- Electrical interference
- Restriction due to wiring
- How accurate as not a “normal nights sleep”



Other Equipment

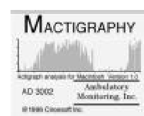
- Watch_PAT

The watch PAT device records 3 signals :PAT (arterial pulse wave volume), heart rate derived from PAT, oxyhemoglobin saturation (SaO2) and wrist activity (Actigraph).

PAT is a newly detected physiological signal that reflects arterial pulsatile volume changes in the fingertip. The PAT signal mirrors changes or anomalies in autonomic nervous system activity. The PAT signal can be measured using a non-invasive finger mounted optical sensor and is analyzed with specialized signal processing algorithms.

Other Equipment

- Actigraph

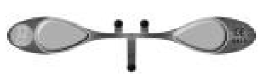


Also known as an activity monitor, detects activity by sensing motion via an internal accelerometer or mercury switch.

This small lightweight single axis activity-measuring instrument can be worn on the wrist, waist, or ankle to record physical activity.

Other Equipment

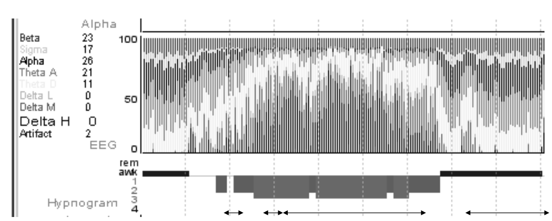
- Sleep Strip



Cheap and cost effective!
Also known as an activity monitor, detects activity by sensing motion via an internal accelerometer.

This small lightweight single axis activity-measuring instrument can be worn on the wrist, waist, or ankle to record physical activity.

Example of spectral analysis for sleep stages



awake Stage 2 SWS REM

Present Developments

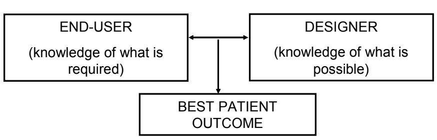
- Oximetry
  - Blue tooth technology
- Eye blinking
  - Car engine turns off if sleepy or car horn sounds
- Algorithms
  - Daily improvement
- Telemedicine
  - Continually scan the patient

Future

- Improvement of treatment options
  - auto adjusting CPAP relatively new
- Better algorithms for measuring all signals
  - reduce manpower and improve accuracy
- External lab systems
  - Telemedicine main option

Future

- Interaction between system designers and end users is paramount to understand requirements and difficulties of design.



How could you help us?

- To fine tune our present technology
- The development of new sensors / techniques / equipment
- Help with specialized research requirements
- The future of the development on the measurement of physical sensors is with you
- What is your dream or idea????
  - We are all ears and we are waiting!!!!

Like to Visit ?

- If you would like to observe a sleep study at night or visit us during the day you are most welcome.
- Please call us on 8345 6124 to arrange

THANKS