

# **State perception in physiological sleep**

Rated versus measured sleep

# Outline

- Definition and criteria of sleep
- Methods to measure sleep
- Discrepancies between measured and rated sleep
- Studies with interviews out of sleep
- Awareness/orientation in sleep
- Conclusions

# **Main criteria of sleep**

Bodily rest

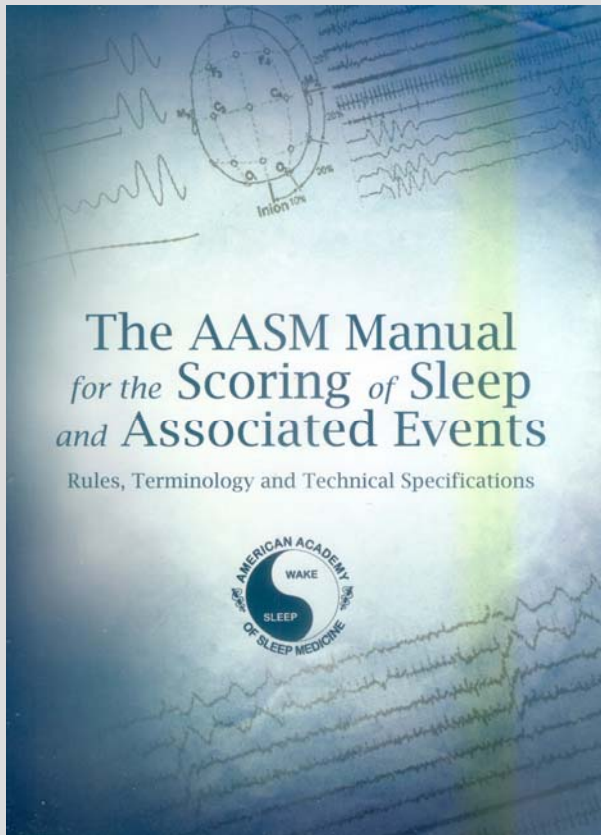
Reduced reactivity

Specific CNS activity

Spontaneous begin and end

# **Sleep as a state of unconsciousness**

- De Manaceïne (1896)
- Kleitman (1929)
- Massimini et al. (2005)



Preface, 1st sentence:

„In its simplest and most positive terms, sleep is a desired state of unconsciousness.“

2007

Ian Oswald defines sleep as:

„It is a healthy state of inertia and  
unresponsiveness ...“

(The Oxford Companion to The Mind.1987, p. 718)

# Methods to measure sleep

Bodily rest	Actimetry
Reduced reactivity	Stimulation, Evoked potentials
Specific CNS activity	Electroencephalography, Polysomnography

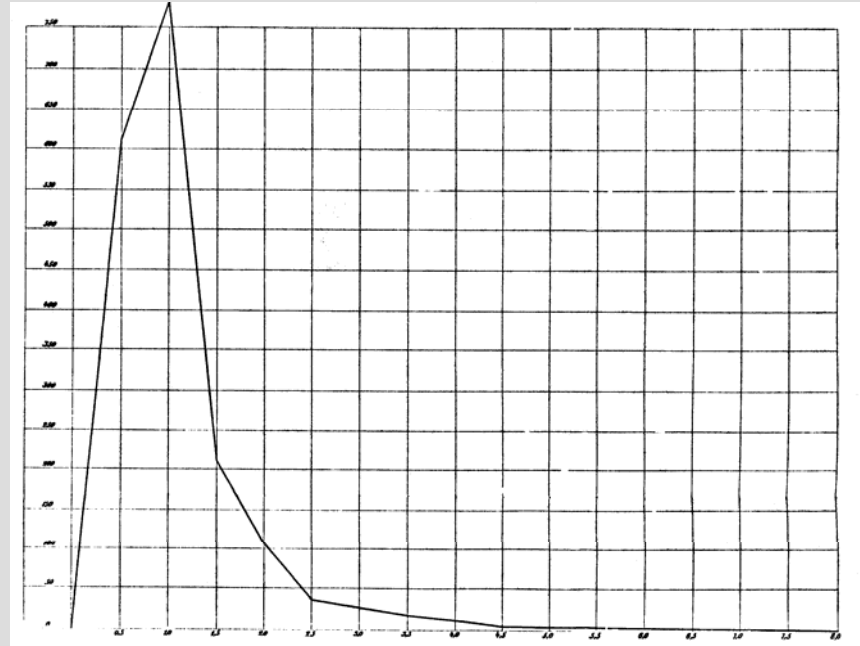
# The arousability varies systematically during sleep



Ernst Kohlschütter:  
An early pioneer in  
sleep research

1862

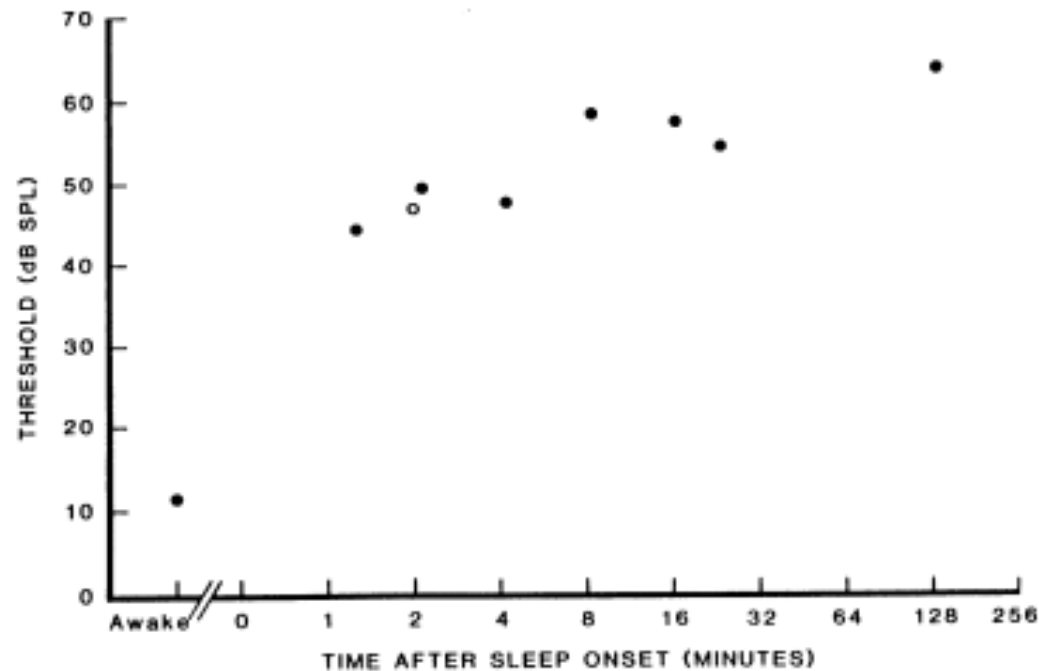
Kohlschütter, E.: Messungen  
der Festigkeit des Schlafes. Z.  
ration. Med., 1862; 17:209-253



Kohlschütter's depth of sleep curve

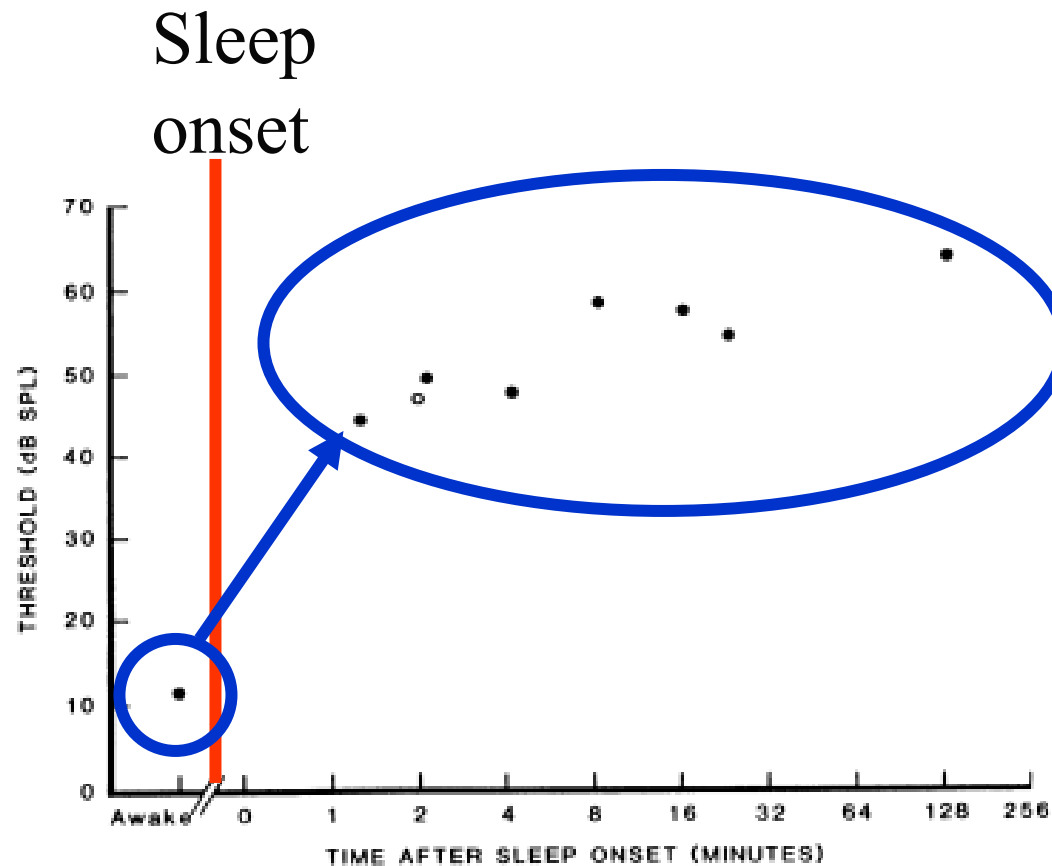


# Arousal threshold increases rapidly with sleep onset



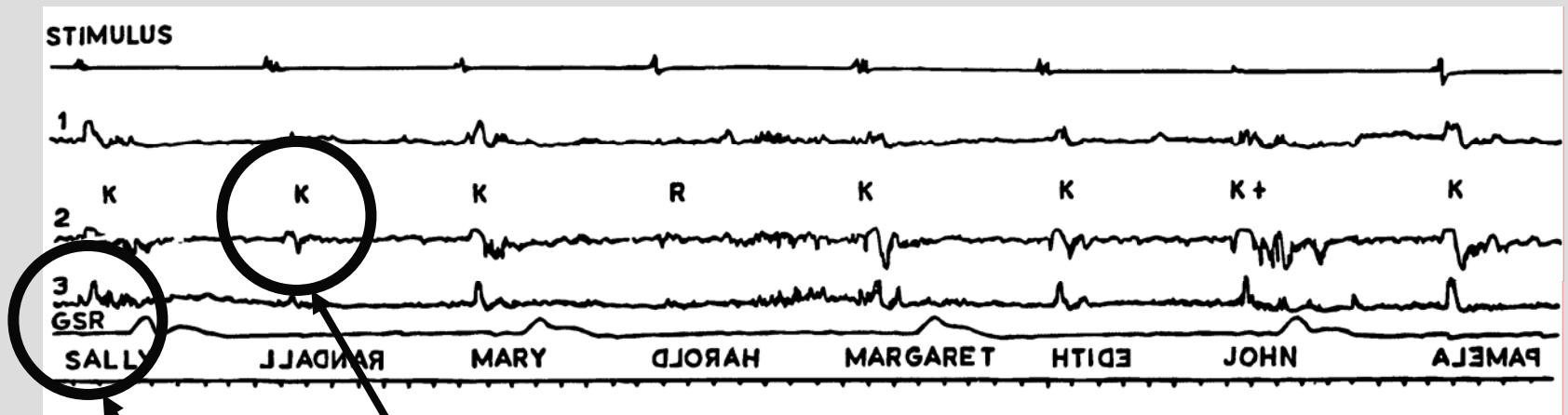
(Bonnet & Moore, 1982)

# Arousal threshold increases rapidly with sleep onset



(Bonnet & Moore, 1982)

# Stimulus discrimination in sleep

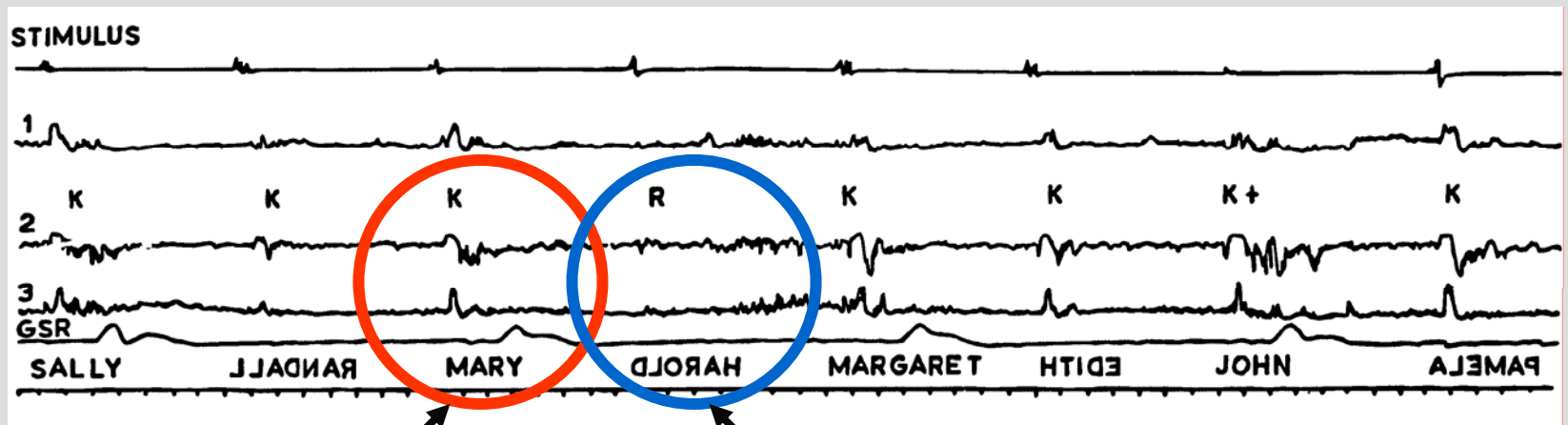


K complex (EEG)

Galvanic Skin Response (GSR)

(Oswald et al., 1960)

# Stimulus discrimination in sleep



(Oswald et al., 1960)

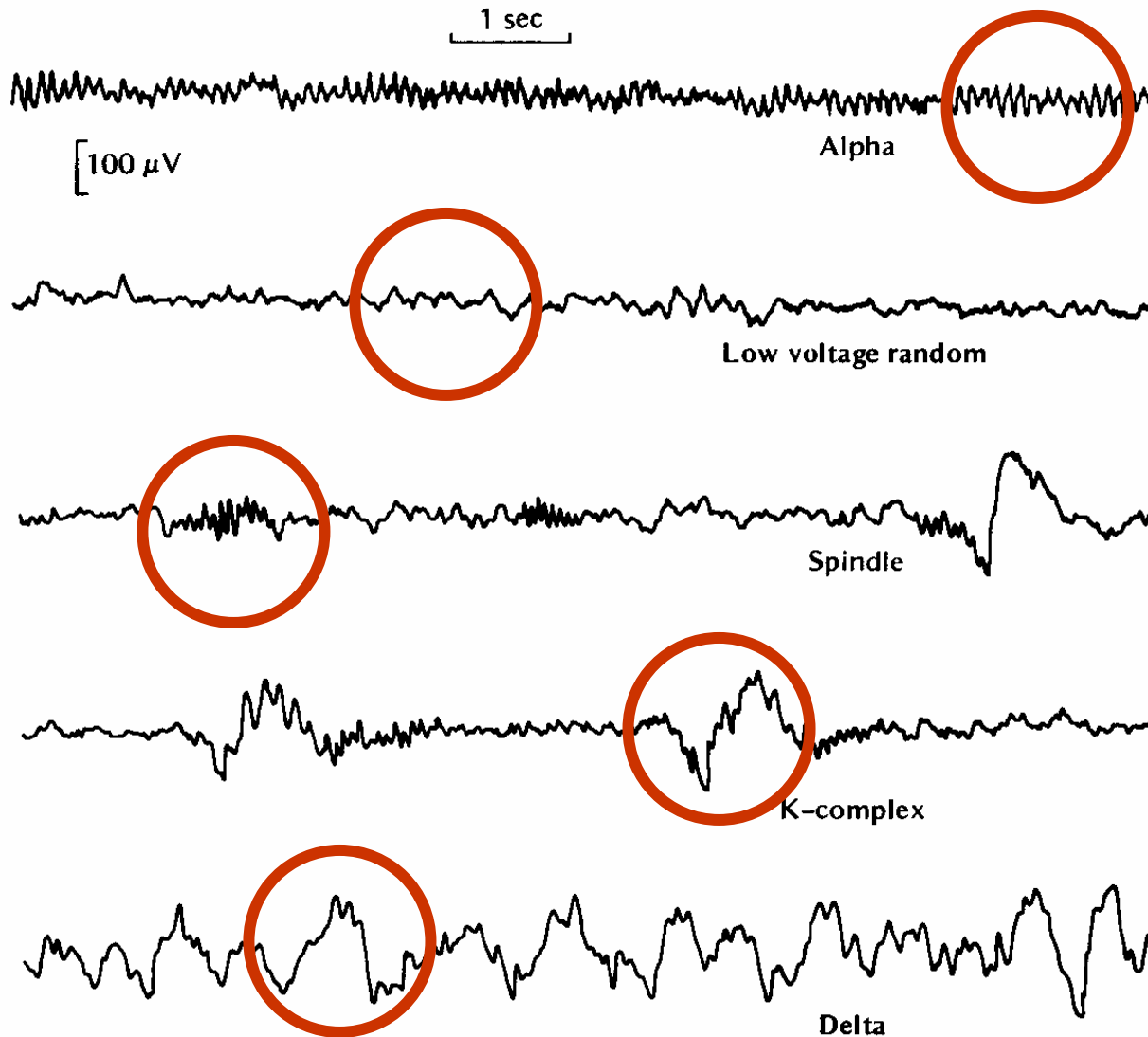
Stimulus  
contains  
information

Stimulus  
contains  
no information

# Recording sleep by measuring the electroencephalogram (EEG)

- Method: Measuring the EEG continuously during sleep.
- Objective: To observe the spontaneous electrical activity of the brain.

# EEG waveforms



Alpha

Theta

Spindles

K complexes

Slow (Delta)  
waves

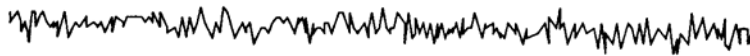
# EEG correlates with mental state

Frequenz-  
bereich (Hz)

EEG - Muster

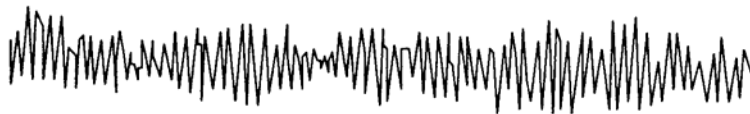
**BETA**

≥ 13  
wach,  
angespannt



**ALPHA**

8 – 12  
wach,  
entspannt



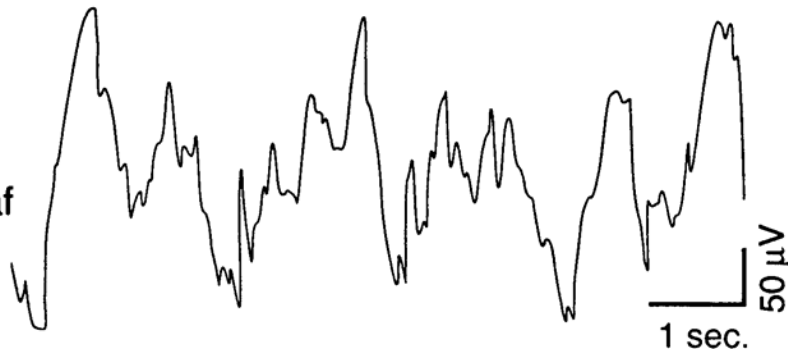
**THETA**

3 – 7  
Dösen



**DELTA**

≤ 2  
Tiefer Schlaf



Active / tense  
wakefulness

Relaxed  
wakefulness

Drowsy,  
light sleep

Deep sleep

# Methods to measure sleep

## Recording sleep

### **Polysomnography**

- EEG, EOG, EMG
- ECG, respiration, others

### **Actigraphy**

### **Imaging techniques**

- fMRI, PET

## Reporting sleep

### **Questionnaires**

- Sleep history
- Sleep quality

### **Sleep diaries, Scales**

- Quality of sleep (PSQI)
- Sleepiness (SSS, ESS)

### **Mental content, dream reports**



# Measured versus rated sleep

Sleep parameter	Anamnestic interview	Sleep diary	PSG
Sleep latency (min.)	75	25	19,5
Sleep duration (min.)	240	360	392
Wake after sleep onset (Min.)	45	30	4,3

(Paterok & Weglage, 1993)

# Measured versus rated sleep

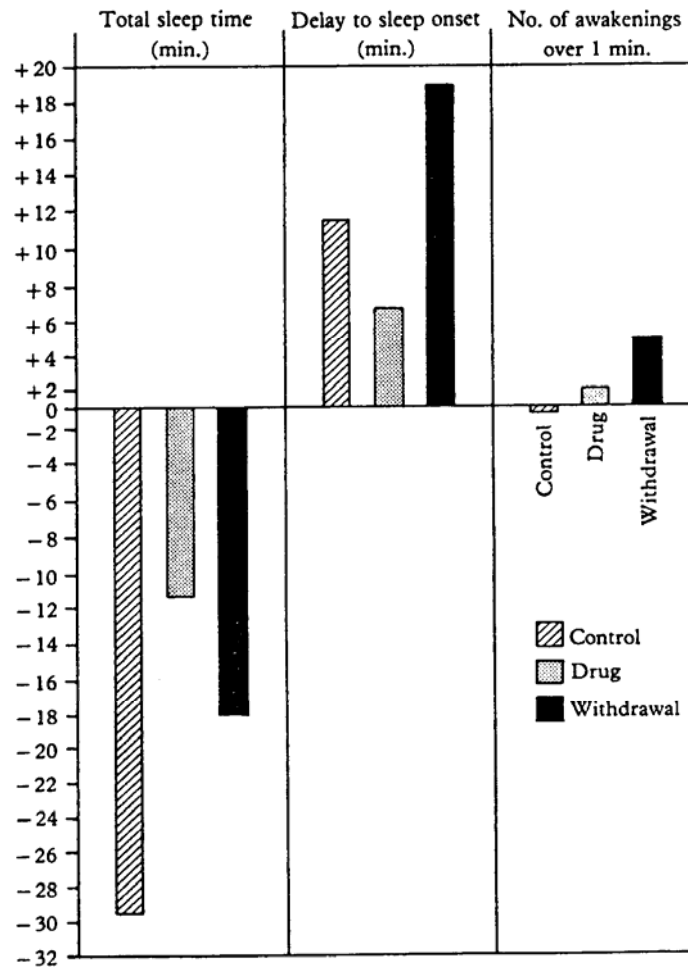


Fig. 2. Mean judgement tendency (overestimation or underestimation) of subjects during the control, drug and withdrawal phases.

(Lewis, 1969)

# Measured versus rated sleep

- There may be discrepancies between measured sleep and rated sleep.
- These discrepancies are more pronounced in patients with insomnia, compared to normal subjects.
- The most obvious case is sleep state misperception (ICSD 1) or pseudoinsomnia (ICSD 2).

# Getting state estimations from interviews after awakenings

Sewitch (1984), Mendelson (1995), and Mercer et al. (2002) observed an appreciable perceptual uncertainty of having slept in groups of normal subjects. This phenomenon was state dependent.

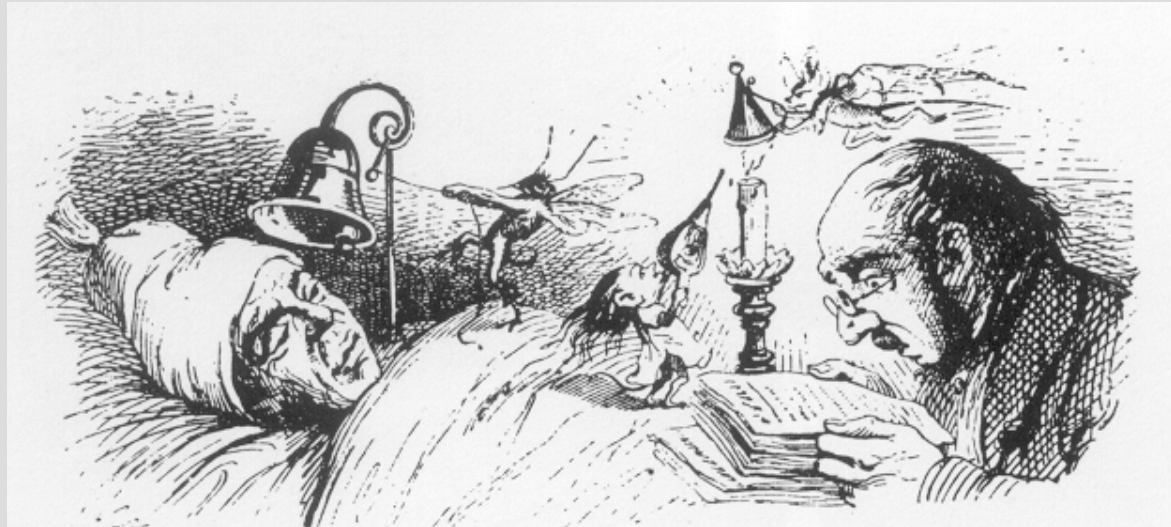
# Nighttime interviews in normal subjects

## Design of the study:

- 22 subjects (16 f, 6 m; mean age:  $24.3 \pm 3.5$  years)
- 1 night in the sleep laboratory (PSG)
- 4 „awakenings“ from different states

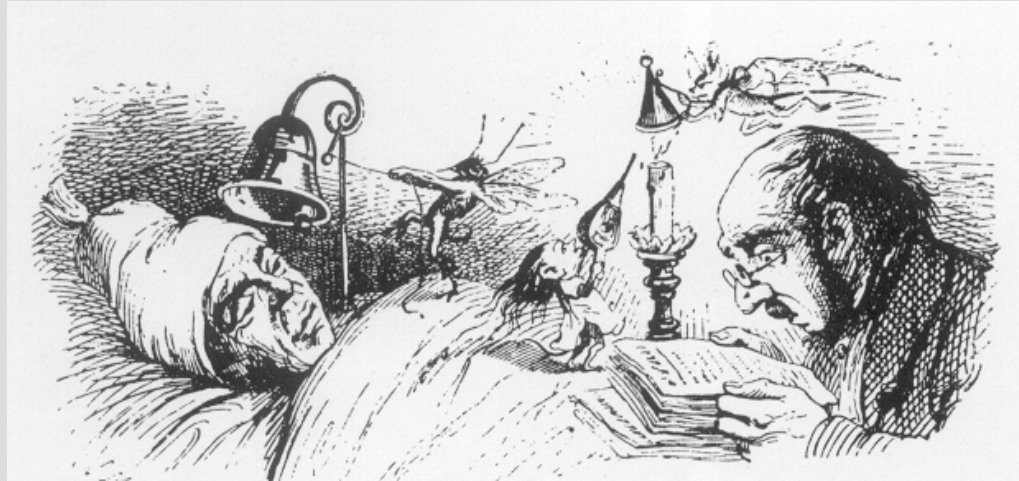
(Amrhein & Schulz, 2000)

# Questions



„Were you awake or did you sleep before you heard the tone signal?“

# Questions



If awake:

„Was there something in your mind?“

# Questions



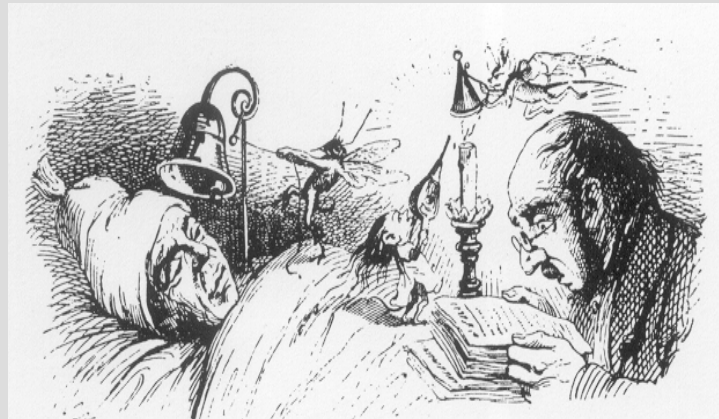
If yes:

\_\_\_\_\_ „Was it -

- clear/distinct or vague/indistinct?
- image-like or thought-like?
- controllable or uncontrollable?“



# Questions

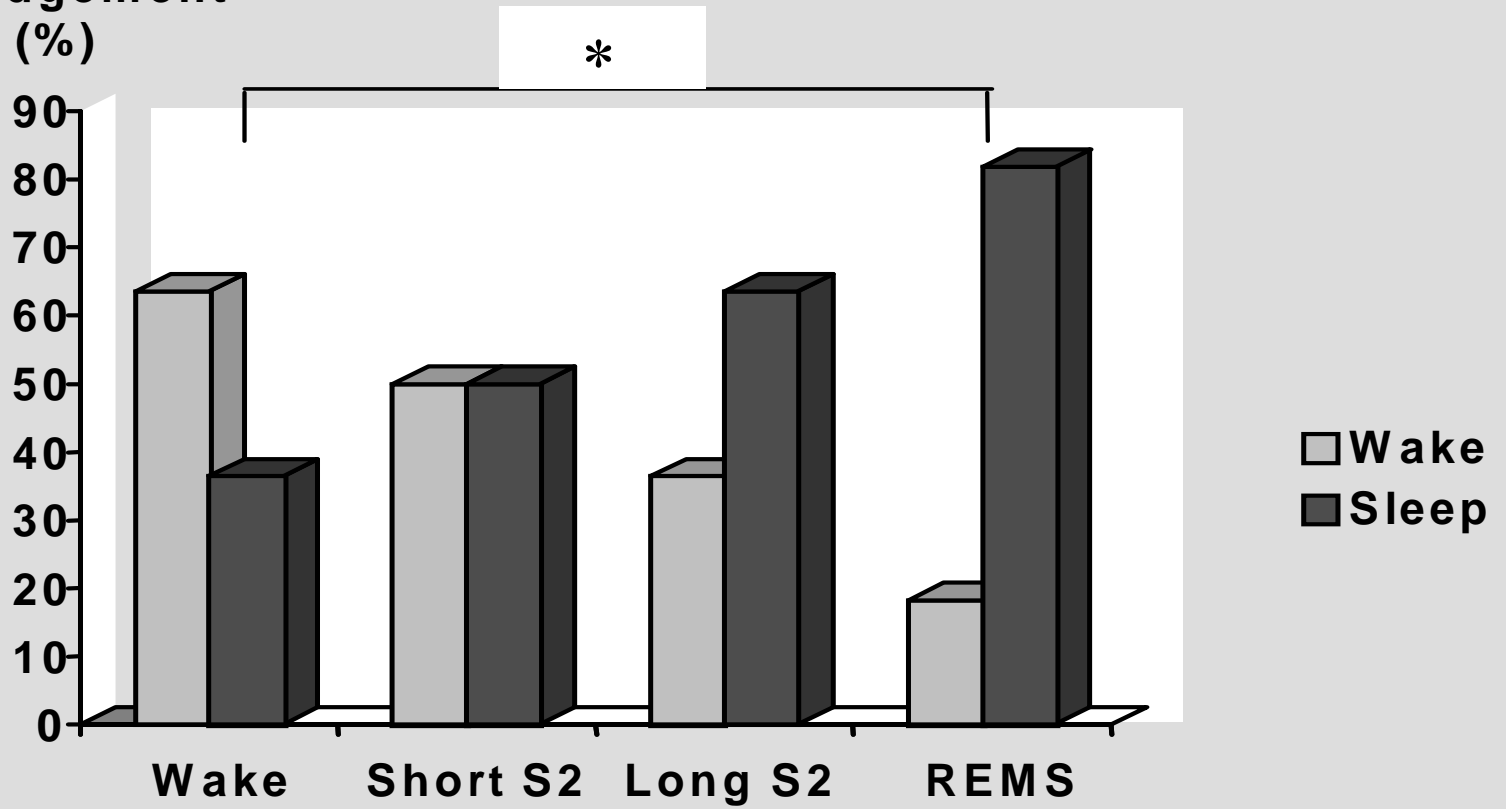


„Did you know, where you are and where things around you are located?“

## Four „awakening“ conditions

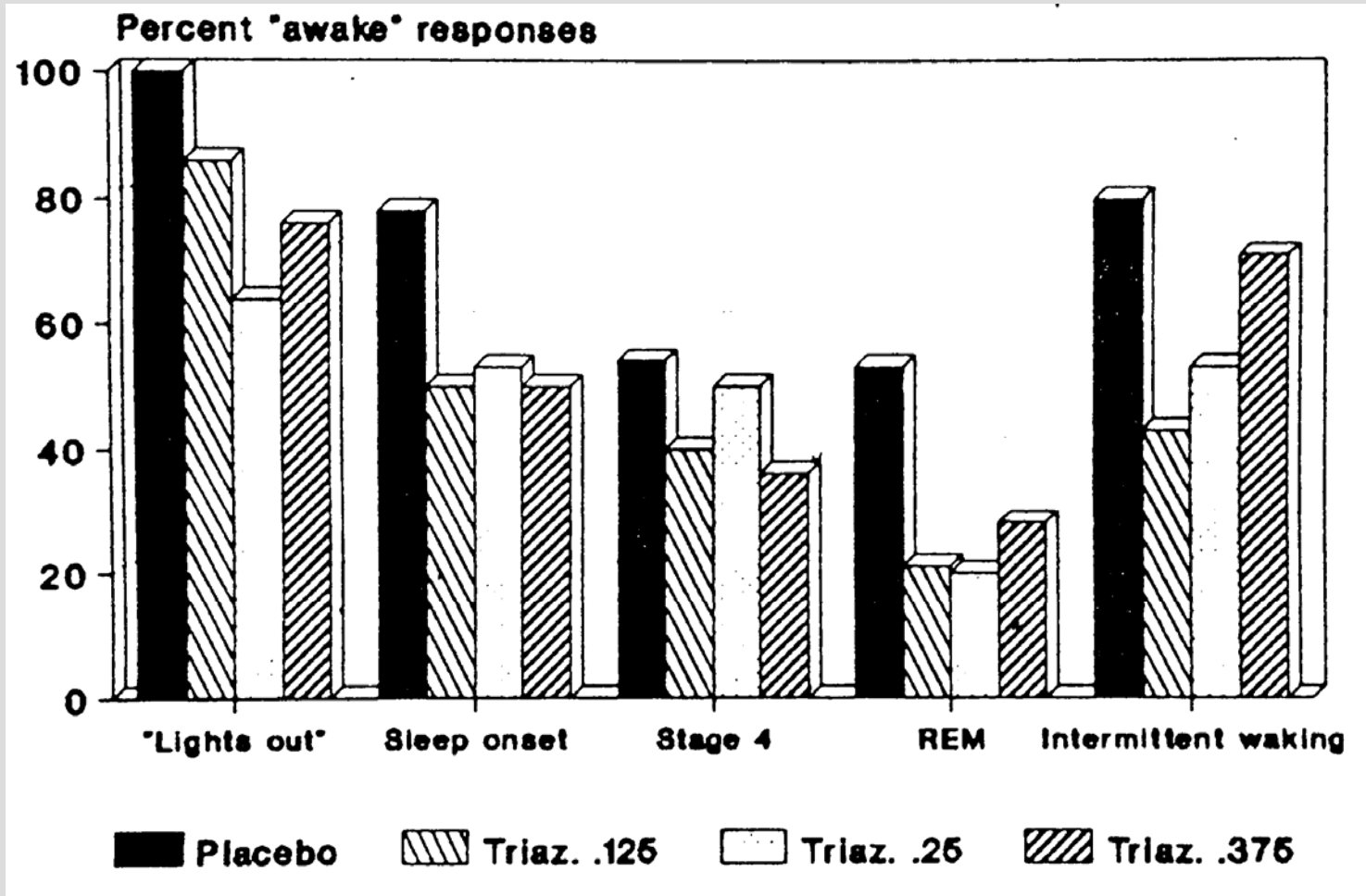
- Wake/Arousal:** 20 sec alpha EEG, or movement time after >10 min of stage 2 sleep.
- Short stage 2:** 4 - 8 min of sleep stage 2 after the last 30 sec of EEG alpha activity.
- Long stage 2:** 15 min sleep stage 2 after the last preceding 30 sec of EEG alpha activity.
- REM sleep:** 5 min of uninterrupted REM sleep.

**Sleep-/wake  
judgement  
(%)**



(Amrhein and Schulz, 2000)

# The effects of a benzodiazepine hypnotic (Triazolam) on state perception



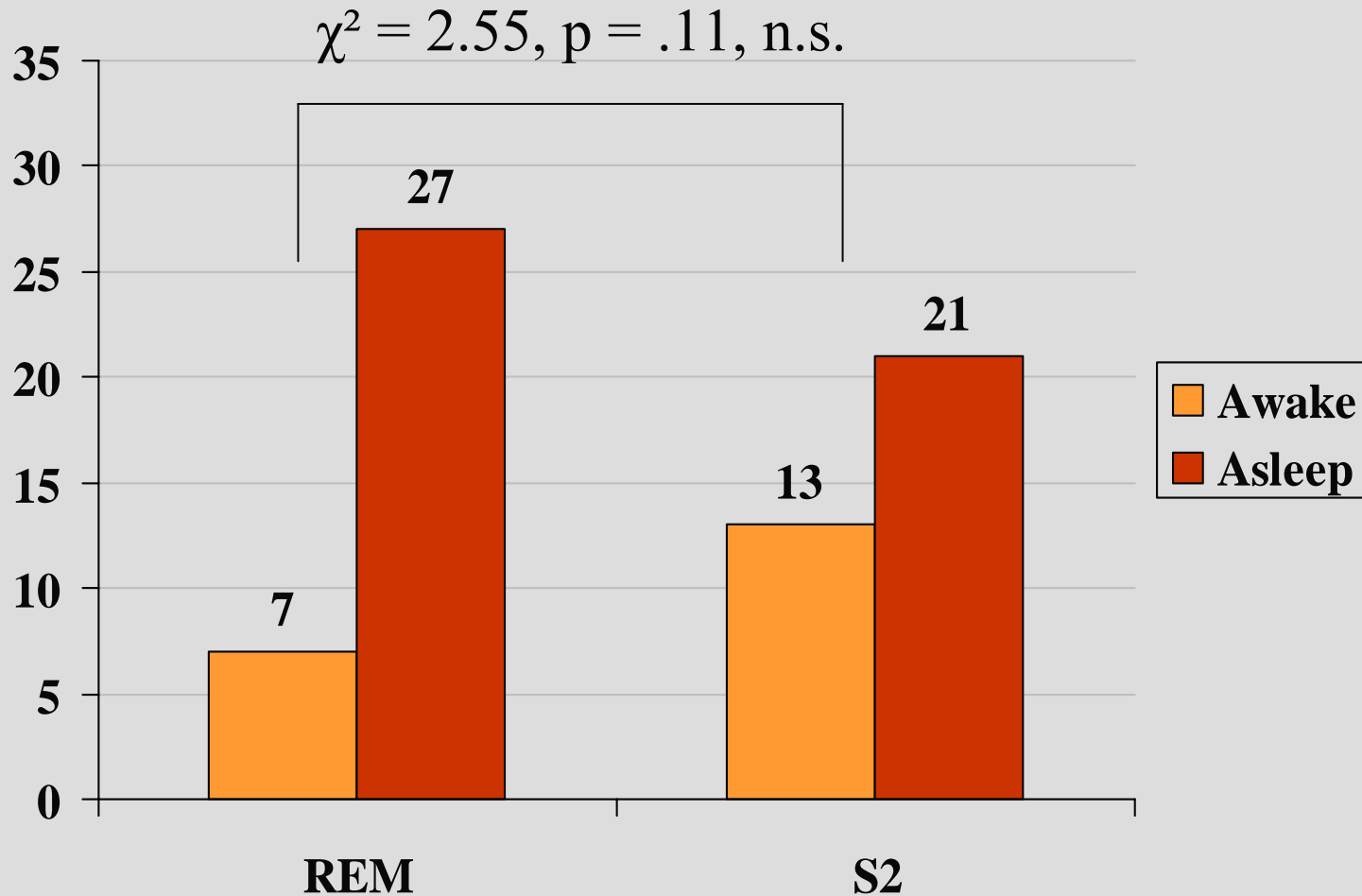
(Mendelson, 1993)

# Design of a replication study

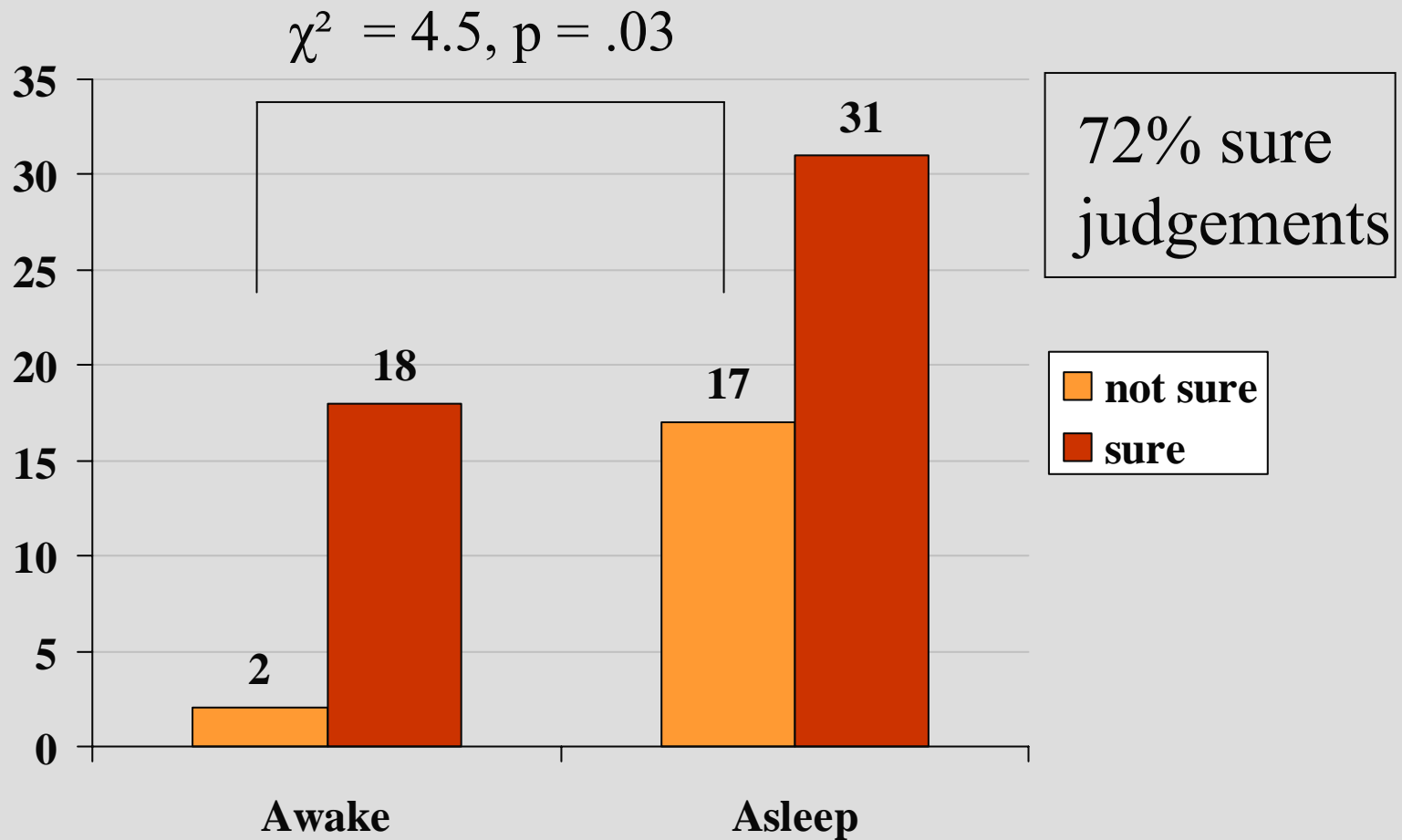
(Weigand et al.)

- 68 young, healthy subjects (mean age: 24.1 years; 43 f, 25 m)
- One „awakening“ either from stage 2 or REM sleep.
- At least 15 minutes of uninterrupted S2 sleep.
- At least 7.5 minutes of uninterrupted REM sleep.

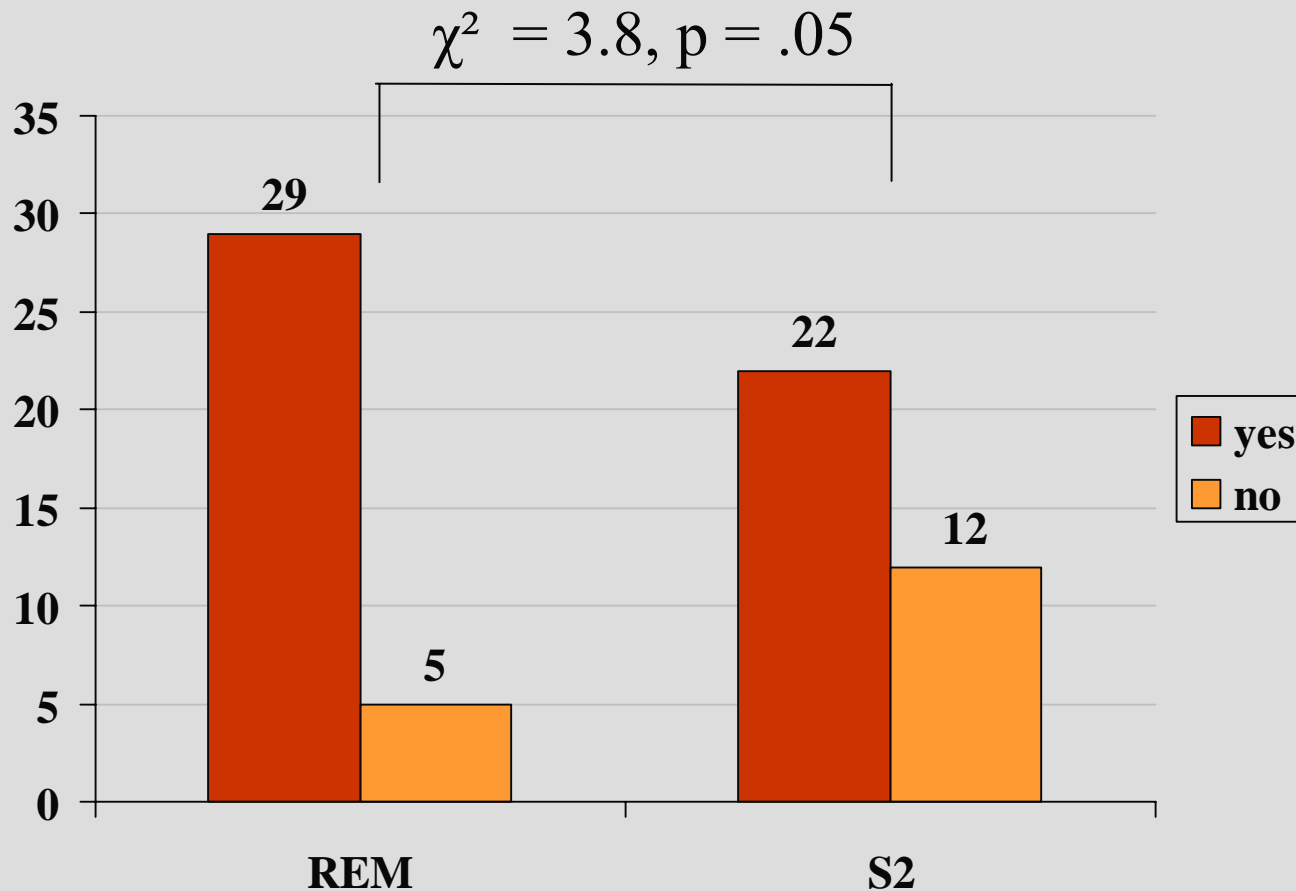
# Were you asleep or awake?



# Are you sure or not sure?

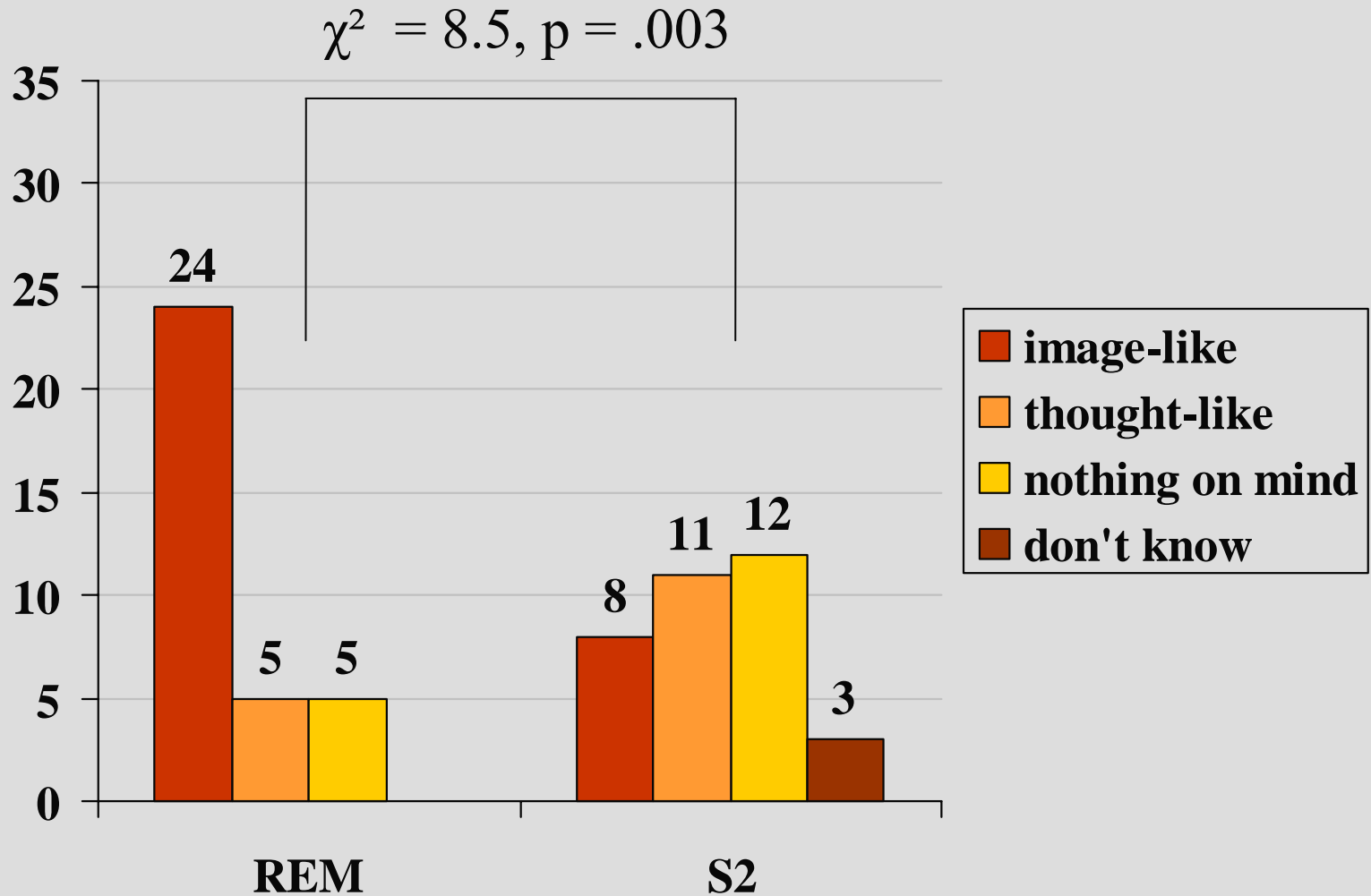


# Was there something on your mind before you heard the tone?





# Mentation: Image-like or thought-like?

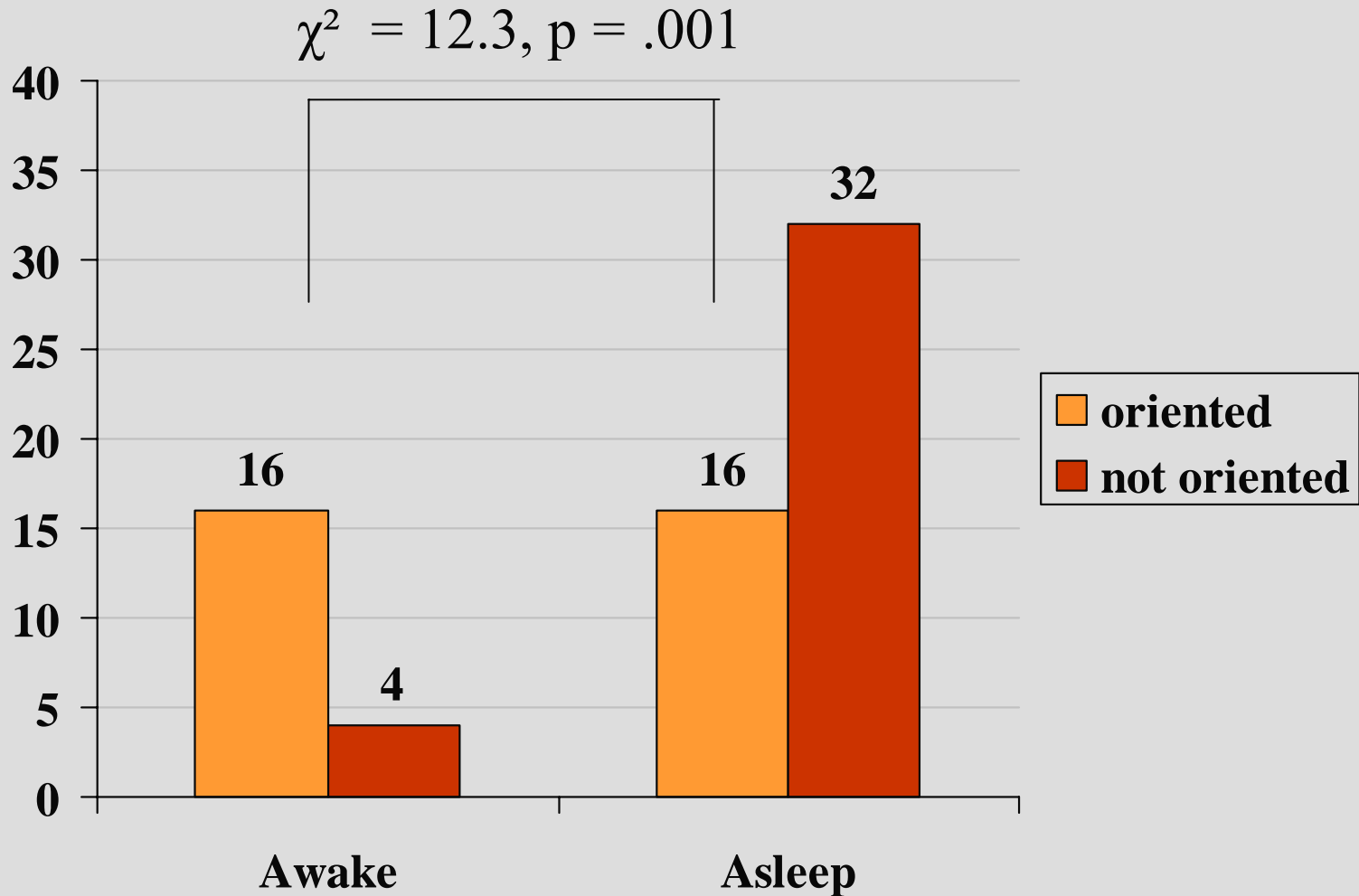


## Time of night

Stage 2 sleep: The percentage of awake judgements did not differ between early and late awakenings.

REM sleep: There were significantly more awake judgements in late than in early sleep (35.3% vs. 5.9%).

# Awareness / Orientation



# Deliberate Awakening in Patients with Sleep Disturbances

## Design:

- One awakening in the 2nd PSG
- Awakening out of S2 (>10 min) or REMS (>5 min)

## Sample:

- N = 84 Patients (53 Females, 31 Males)
- Mean age: 51 yrs., range: 21 - 72 yrs.

# Diagnostic groups

Diagnoses:	Number (N)
• <u>Daytime sleepiness (EDS)</u> (Narcolepsy, Hypersomnia)	24
• <u>Disorders of initiating and maintaining sleep (DIMS)</u> (Insomnia, RLS)	46
• <u>Other sleep disorders</u> (Parasomnias, others)	14

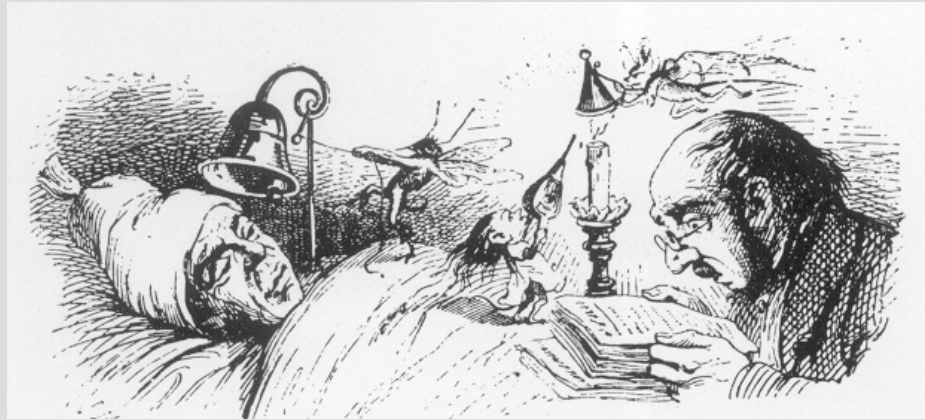
# Sleep / wake judgements in patients

Prior state was judged as -		S2 (N = 45)		REMS (N = 39)
- Sleep	28	62.2%	35	89.7%
- Awake	16	35.6%	3	7.7%
- No decision	1	2.2%	1	2,6%

# Certainty of sleep judgement

Prior state was sleep:	<u>S2</u> (N = 28)		<u>REMS</u> (N = 35)	
Absolutely sure	17	60.7%	18	51.5%
Quite sure	11	39.3%	11	31.4%
Not so sure	-	-	6	17.1%

# Why was the state perceived as sleep?



Question:

“On which impressions is your judgement based?”



# Why was the state perceived as sleep?

	<u>S2</u> (N = 28)	<u>REMS</u> (N = 35)
No response	14 (50.0%)	5 (14.3%)
Feeling of having slept	7 (25.0%)	8 (22.9%)
Reporting of being woken up	4 (14.3%)	9 (25.7%)
I was dreaming	3 (10.7%)	13 (37.1%)

# Dreaming and thinking while sleeping



If the prior state was rated as sleep:

“Was there something in your mind, before I entered the room?”

# Dreaming and thinking while sleeping

Question: „Was there something in your mind, before I entered the room?“

	<u>S2</u> (N = 28)		<u>REMS</u> (N = 35)	
No	23	(82.1%)	17	(48.6%)
Dream	5	(17.9%)	15	(42.8%)
Thoughts	-	-	3	(8.6%)

# Sleep perception depends on diagnosis

	<u>S2</u>				<u>REMS</u>			
	Sleep		Wake		Sleep		Wake	
	N=28	%	N=16	%	N=35	%	N=3	%
<b>EDS</b>	10	<b>83.3</b>	2	<b>16.7</b>	11	91.7	1	8.3
<b>DIMS</b>	13	<b>52.0</b>	12	<b>48.0</b>	18	90.0	2	10.0
Others	5	71.4	2	28.6	6	100.0	-	-

EDS: Excessive Daytime Sleepiness

DIMS: Disorders of Initiating and Maintaining Sleep

# Sleep perception depends on diagnosis

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DIMS: Disorders of Initiating and Maintaining Sleep

# Summary (1)

- Sleep perception is state dependent.

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# Summary (1)

- Sleep perception is state dependent.
- Patients with sleep complaints perceive REM sleep as sleep in about 90%, and S2 sleep in about 50% to 80% of all awakenings, depending on diagnosis.
- In S2 sleep significantly more awake judgements were made by DIMS than by EDS patients.
- The spontaneous mentioning of dreams was quite high (about 50%) if the prior state was REM sleep, and low (<20%) in S2 sleep.

## Summary (2)

- The percentage of sleep / wake judgements was quite similar in patients with sleep complaints and young non-complaining subjects.

## Summary (2) and Conclusion

- The percentage of sleep / wake judgements was quite similar in patients with sleep complaints and young non-complaining subjects.
- We assume that subjects misperceive physiological sleep as wakefulness if the content of their cognitive activity is similar to or indistinguishable from thoughts during wakefulness (Continuity hypothesis).

# The End



Thanks to the students of the Free University Berlin and to the staff of the sleep laboratory, Helios Klinikum, Erfurt.

# Questionnaire on awareness/ orientation during sleep

- Originally 17 questions about how well a person can disengage during wake and sleep.
- Final version with 10 questions, measuring two dimensions:

Factor 1: Awareness of the surrounding

Factor 2: Sensitivity and worrying

# Type of questions and answering categories

**Instructions:** The following questions ask about how well you can disengage during wake and sleep. Please put a cross in the box that best describes the situation for you. Please answer all the questions. If a situation doesn't seem to apply to you, please try to respond as you think you might in that situation.

	Always	Often	Seldom	Never
1. I can shut off well.				
2. I sleep soundly.				
3. I am unaware of the environment once asleep.				

...  
...  
...  
...

# **Factor 1: Awareness of the surrounding (outside orientation)**

## Questions agreed:

- + During sleep I remain sensitive to things around me.
- + At night in bed I realise when it starts to rain or there is a thunder storm.
- + During the night I become aware when other people move around the house.

# **Factor 1: Awareness of the surrounding (outside orientation)**

## Questions denied:

- I sleep soundly.
- Even in unfamiliar surroundings my sleep is sound.
- I am unaware of the environment once asleep.



## **Factor 2: Sensitivity and worrying (inner orientation)**

### Questions agreed:

- + I am more thin-skinned than thick-skinned.
- + At night in bed I have many thoughts going round in my head.
- + I worry a lot.

### Question denied:

- I can shut off well.