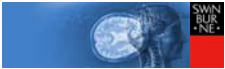


Individual Differences in EMF Provocation Studies on Sleep

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Presentation Overview

Introduction

- Sleep and the EEG
- What is the issue?
- Previous research on mobile phones and sleep

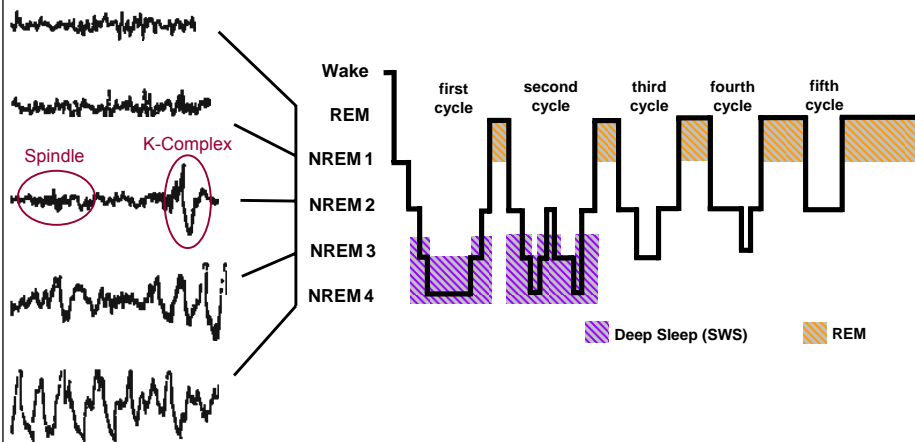
Exploring individual differences

- Research questions
- Methods
- Results

Discussion

- Summary of results
- Ramifications for current methodologies
- Ramifications for health
- Future research

Why is Sleep a Good Tool?



Sleep and RF EMF

Sleep disturbances and fatigue the most common symptoms

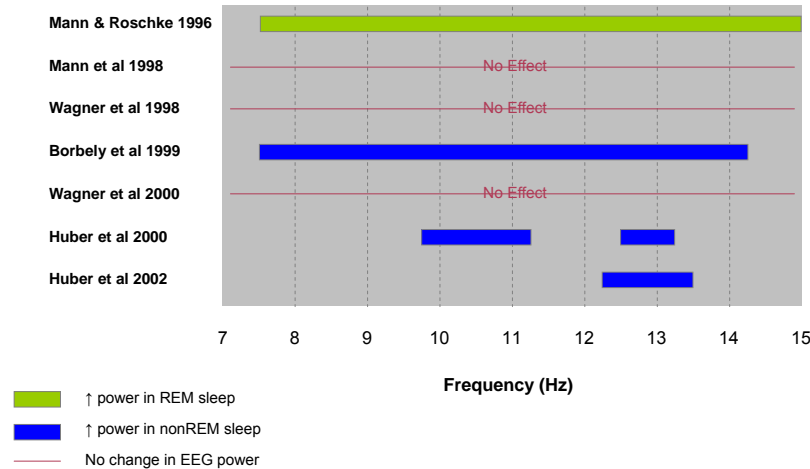
Human provocation studies:

- No apparent or consistent effect on typical sleep variables
- Somewhat consistent effect on the EEG during nonREM sleep
- No evidence of an effect on sleep quality

Question remains:

- Do mobile phones affect the sleep EEG?

Sleep EEG and RF EMF: Early Research



Sleep and Mobile Phones: Our Previous Results

Research Questions:

- Does exposure to RF EMF lead to changes in conventional sleep parameters?
- Does exposure to RF EMF lead to enhancements in EEG spectral power during nonREM sleep (11.5 – 12.25 Hz, 12.25 – 13.5 Hz, and 13.5 – 14 Hz sub-bands), and what is the time-course of this effect?
- Does exposure to RF EMF alter the EEG during REM sleep?

Loughran et al., 2005

Exposure System

Modified Nokia 6110 handset

- Attached using a head cradle
- Position to simulate normal use
 - speaker located over the auditory canal
 - antenna situated over temporal region
 - microphone aligned towards the corner of the mouth



Set via laptop

- Continuously transmit at peak power (2 W, mean output of 0.25 W)

Emitted Signal

- 894.6 MHz RF field (pulsed at 217 Hz; duty cycle of 12.5%; pulse width of 576 μ s; 26th frame not idle)
- Auditory circuits disconnected; padding between handset and cover

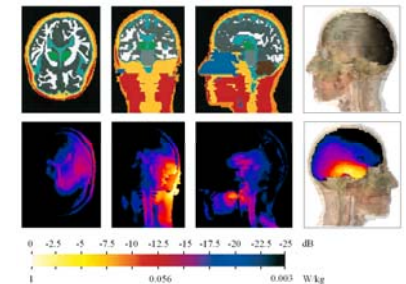
Detailed Dosimetric Evaluation of Exposure System

Peak spatial SAR

- Averaged over 1g = 0.19 W/Kg

Distribution of SAR

- Localized exposure of the upper cheek and inner ear regions, and concentrated on a limited area of the middle temporal gyrus just above the ear.



Boutry et al., 2008

Study Design

Participants:

- N=50 (27 Males, 23 Females; 18-60 yrs)

Procedure:

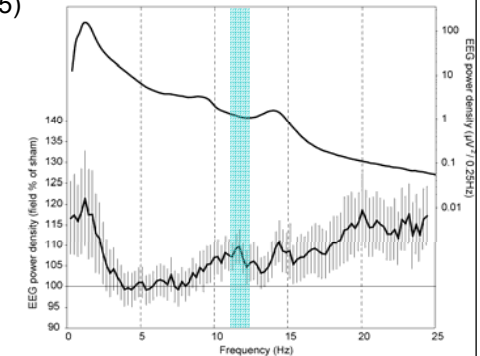
- Double-blind, randomized, crossover design
- 2 experimental nights (sham and active)
- 30 minutes exposure
- Full night polysomnographic recording

Data Analysis:

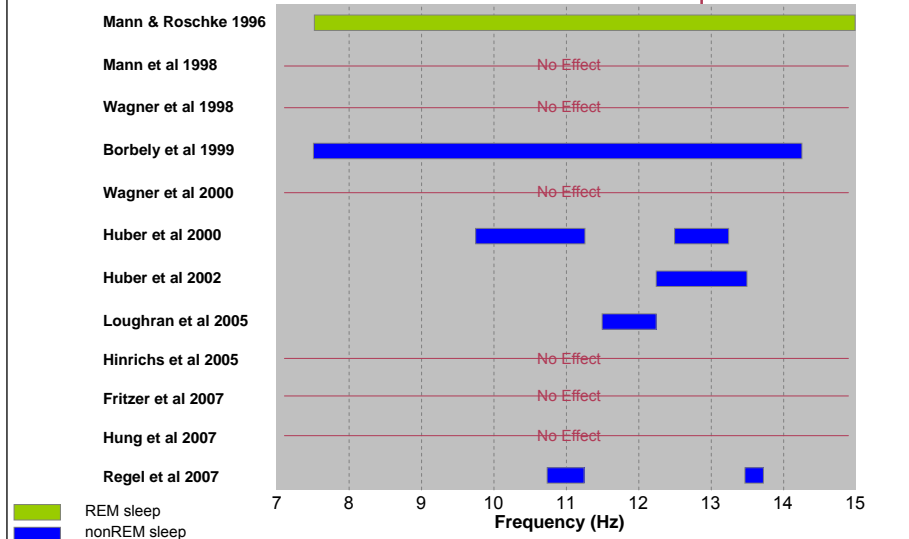
- Sleep scored according to standard criteria
- Spectral analysis of EEG channels

Results

- ↓ REM latency (~ 17 mins)
- No change in other conventional sleep parameters (e.g., total sleep, sleep onset, arousals, etc)
- ↑ EEG power density in the 11.5–12.25 Hz frequency range (partial $\eta^2 = 0.105$)
- No EEG changes in subsequent nonREM periods
- No EEG changes during REM sleep



RF EMF & Sleep EEG: Current State of Research



Why the Variation?

Differences in exposure parameters

- Length of exposure
- Exposure source
- SAR of exposure
- Localised vs. homogenous exposures

Differences in study design

- Sleep measurement

Magnitude of effect

- Sample size

Statistics

- Multiple comparisons

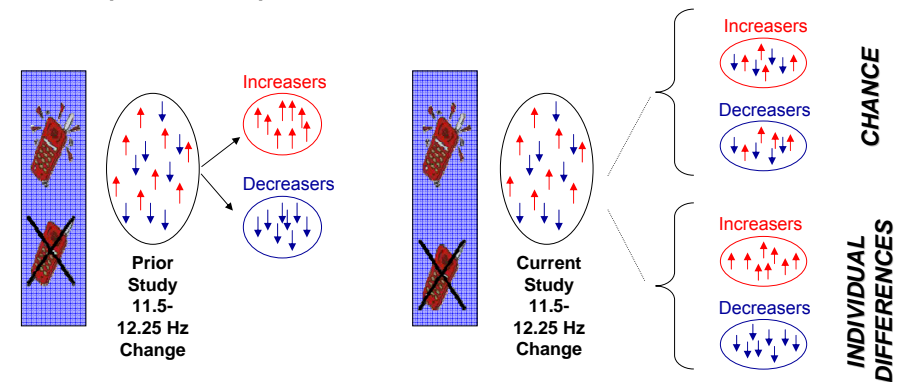
Individual differences

Individual Differences

1. Inter-individual differences in the EEG
 - Individual alpha frequency varies considerably between subjects
 - Large inter-subject variation in sleep spindle peak frequency
 - Use of fixed/traditional frequency bands mean that frequency specific effects could go undetected
2. Individual response to RF EMF
 - Some participants may be effected more by exposure
 - Some participants may not be effected

Current Project

Are individuals effected differently by mobile phone exposure?



Sleep and Mobile Phones: Current Study

Research Questions:

Primary endpoints (hypothesis driven):

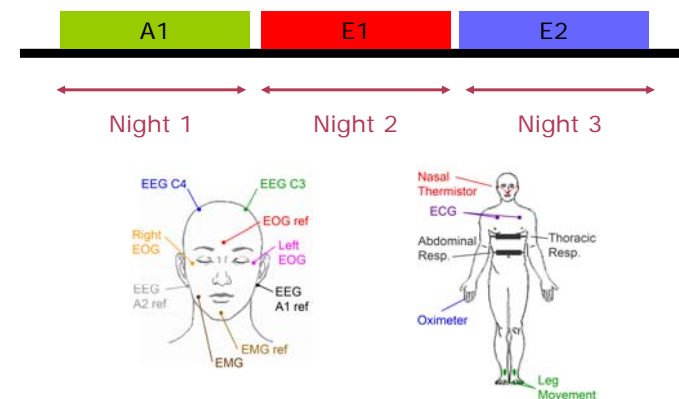
- Are the effects of exposure replicable within individuals?
- Does exposure to RF lead to an overall enhancement in EEG spectral power in nonREM sleep (11.5 – 12.25 Hz)?

Secondary endpoints (exploratory):

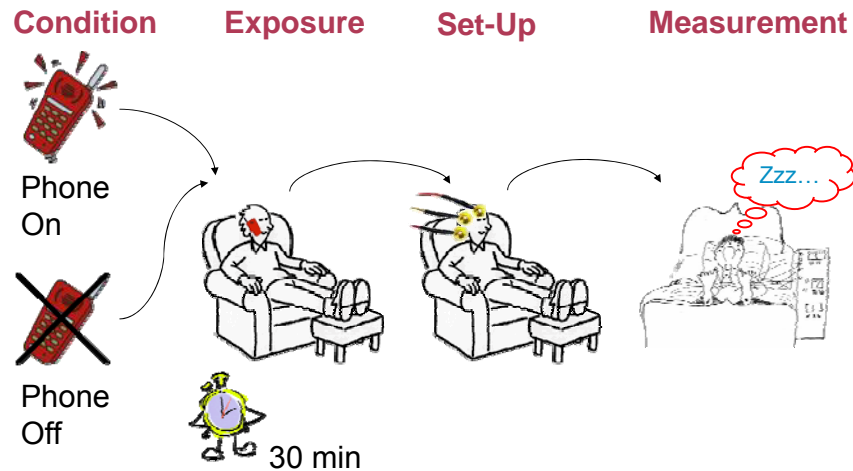
- Does exposure to RF alter the EEG in other frequency ranges (12.25 -13.5 Hz, 13.5 -14 Hz)?
- Does exposure to RF lead to changes in sleep architecture (REM latency)?

Study Design

N = 20 (participants from original study)



Study Design



Data Analysis

Participants

- 20 of original 50 (age 20-51 yrs; 13 female)
- 8 Responders vs. 12 Non-Responders

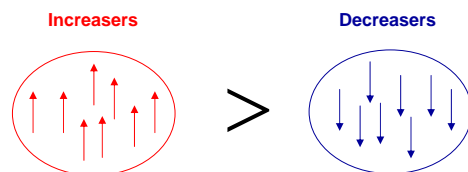
Spectral analysis of sleep EEG

- C3/C4 EEG data averaged
- 1st 30 min of 1st nonREM period (FFT, Hanning window, 4s epochs)
- Manual & automatic artefact removal; only artefact-free epochs used for further analysis
- Double-blind analysis

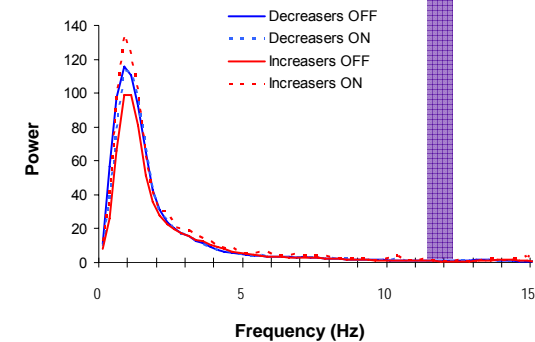
Statistical Analysis

Independent groups t-test (directional)

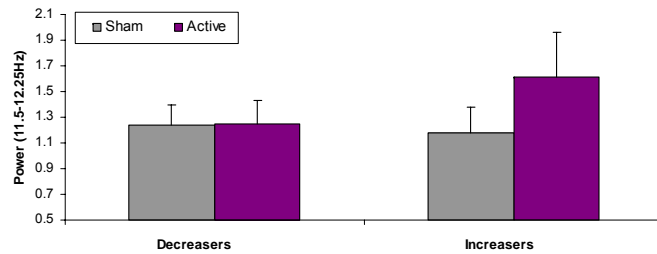
- 11.5 – 12.25 Hz; 1st nonREM period
- IV = Group (responders versus non-responders)
- DV = Change Score (Phone/Sham); Natural Log-transformed



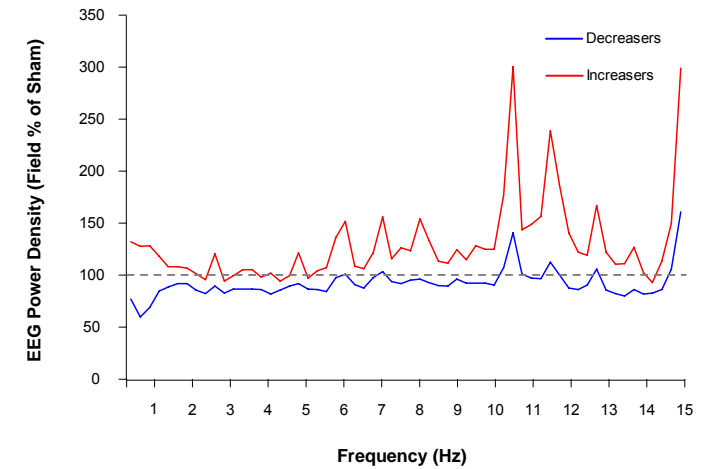
Results



Results



Results



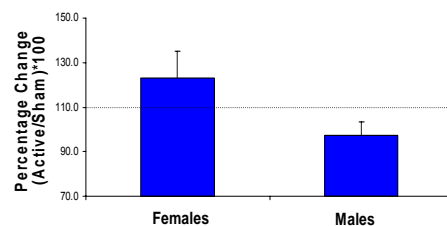
Exploratory Analysis Results

Specificity of frequency

- Divided groups based on 12.25-13.50 Hz
- Divided groups based on 13.50-14.00 Hz

Relations with responder/non-responder

- Age
- Gender; females responded more



Summary of Results

Replicated enhanced sleep EEG following RF EMF exposure

- Adds to the increasing evidence that exposure to the RF EMF emitted by mobile phone handsets alters human brain activity during sleep

Effect was more prominent in previous 'responders' and females

- Supports the hypothesis of individual variation in response to RF EMF exposure

What does this mean?

The effect is susceptible to individual variability

- Provides a possible explanation for previous inconsistent results
- Consistent with a recent study on waking EEG (13 -31% responders) (Hinrikus et al., 2008)

Ramifications for current analysis methods

- Average group analyses may not be the most appropriate technique:
 - Affected frequency range a function of study sample
 - Could lead to a 'masking' of the effect (\uparrow subject variation, \downarrow sample sizes)

What does this mean?

Ramifications for health

- No evidence for changes in sleep architecture or sleep quality
- No evidence that small increases of EEG power in nonREM sleep relates to health

Overall Ramifications

- Research is primarily based on group approach (assumes everyone behaves the same)
- Current results show that RF EMF may have a differential effect
- Therefore, previous human research (cognition, health, etc..) may not be strong evidence that mobile phones have no effect

Future Research

- Individual differences, gender differences?
- Mechanisms of effect?
- Functional significance of effect?
- Long-term effects/consequences?
- New technologies?

Acknowledgements

Swinburne University

Rodney Croft
 Andrew Wood
 Con Stough
 Sumie Leung
 Vanessa Cropley
 Melinda Jackson

Telstra Research Laboratories

Ray McKenzie
 Rob McIntosh
 Steve Iskra
 Nikolas Perentos

IT'IS Foundation

Niels Kuster
 Clementine Boutry
 Albert Romann
 Sven Kühn

Eastern Sleep Disorders Service

Heather Sprigg
 Bruce Thompson

Austin Hospital

Mark Howard
 Tom Churchward

