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DISCAB
Dipartimento di Scienze
Cliniche Applicate
e Biotecnologiche

RADIOFREQUENCIES AND BRAIN

An overview

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*Department of Biotechnological and Applied Clinical Sciences
University of L'Aquila*

SCIENTIFIC MEETING

**Radiofrequencies
and health:**

research in a fast-moving
environment

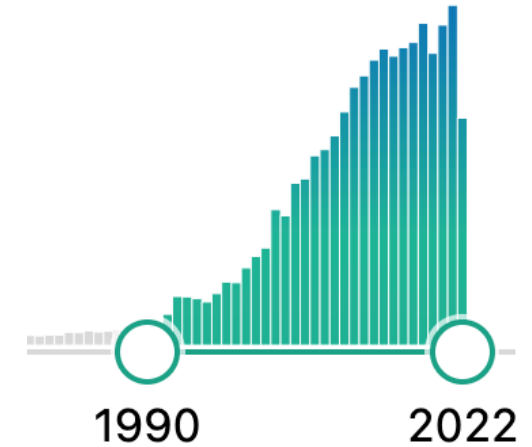
23rd November 2022
Espace Diderot - Paris 12

#RadiofrequenciesRS



Scientific interest in the literature

If we launch a literature search on «radiofrequency and brain functions» on PubMed database, we retrieve more than **2850** items (only in humans)



Scientists were interested at different outcomes of brain functioning and activity:

- Cognition and behavior
- Waking EEG activity
- Sleeping EEG activity



Brain functioning: cognition & behavior

INT. J. RADIAT. BIOL 1999, VOL. 75, NO. 4, 447–456

Effect of a 915-MHz simulated mobile phone signal on cognitive function in man

A. W. PREECE^{†*}, G. IWI[†], A. DAVIES-SMITH[†], K. WESNES[‡], S. BUTLER[§], E. LIM[¶]
and A. VAREY[¶]



A speeding up of performance was observed more strongly during analogue than digital RF exposure.

Outcome variable	Contributing variables
Reaction times on attentional tasks	<ol style="list-style-type: none">1. Simple reaction time2. Choice reaction time ←3. Vigilance reaction time
Speed on working and secondary memory tasks	<ol style="list-style-type: none">1. Spatial working memory reaction time2. Numeric working memory reaction time3. Delayed picture recognition reaction time4. Delayed word recognition reaction time
Accuracy on working and secondary memory tasks	<ol style="list-style-type: none">1. Delayed word recognition sensitivity index2. Immediate recall accuracy3. Delayed recall accuracy4. Numeric working memory sensitivity index5. Delayed picture recognition sensitivity index6. Spatial memory sensitivity index
Accuracy on attentional tasks	<ol style="list-style-type: none">1. Choice reaction time accuracy2. Vigilance accuracy

Effects of 902 MHz electromagnetic field emitted by cellular telephones on response times in humans

Mika Koivisto,^{1,4,CA} Antti Revonsuo,^{1,3} Christina Krause,^{1,4,5} Christian Haarala,^{1,4} Lauri Sillanmäki,^{1,6} Matti Laine^{1,2} and Heikki Hämäläinen^{1,4}

There is a facilitatory effect on brain functioning, especially in some tasks requiring attention and manipulation of information in working memory

Task	RF-off	RF-on	<i>p</i> value
	Mean	Mean	
SRT	282	273	0.026
2-CRT	418	416	<1.000
10-CRT	683	696	0.072
Subtraction	927	912	0.492
Subtraction time	245	216	0.044
Sentence verification	703	681	0.412
Verification time	285	266	0.325
Vigilance	517	492	<0.001
Shape detection	521	521	0.757
Object detection	527	531	0.593
Object familiarity detection	641	635	0.980
Semantic picture categorization	552	546	0.766
Semantic word categorization	600	592	0.703
Object name retrieval	833	822	0.600

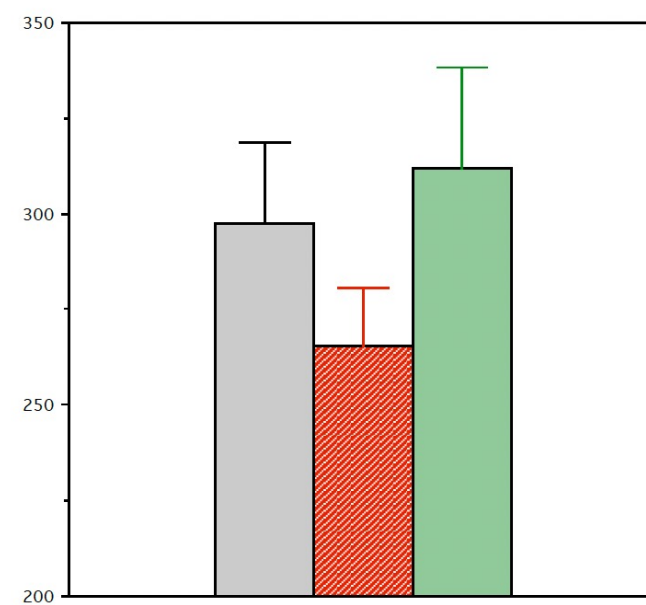
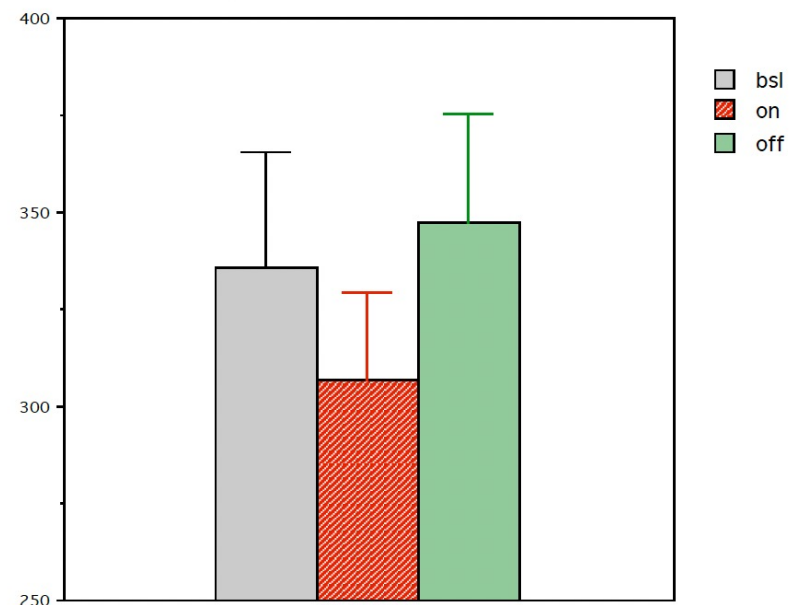
Time-course of electromagnetic field effects on human performance and tymphal

G. Curcio,^{CA} M. Ferrara,^I L. De Gennaro, R. Cristiani, G.

Table I. ANOVA results for the median of reaction times and mean (\pm s.e.) of speed and accuracy measures of letter cancellation task (LCT) and descending subtraction task (DST), under different conditions.

	BSL	EMF-ON	EMF-OFF	F	df	p
Simple reaction times	297.6	265.56	312.08	6.437	2, 36	0.004
Choice reaction times	335.67	306.83	347.27	5.797	2, 30	0.007
LCT speed	19.58 \pm 1.04	19.20 \pm 0.88	19.80 \pm 0.92	0.689	2, 34	n.s.
LCT accuracy	0.919 \pm 0.01	0.925 \pm 0.01	0.930 \pm 0.01	1.206	2, 34	n.s.
DST speed	50.216 \pm 4.09	478 \pm 4.07	49.216 \pm 4.64	0.753	2, 36	n.s.
DST accuracy	0.889 \pm 0.02	0.887 \pm 0.02	0.908 \pm 0.02	1.405	2, 36	n.s.

Reaction time data are reported in milliseconds; speed measures are indicated as the number of explored rows (LCT) and the number of subtractions (DST); accuracy measures are reported as the proportion of correct responses (LCT) and the proportion of correct subtractions (DST).



Facilitatory effect on both vigilance and attention

Effect of a 902 MHz Electromagnetic Field Emitted by Mobile Phones on Human Cognitive Function: A Replication Study

Christian Haarala,^{1,2*} Linda Björnberg,^{3,4} Maria Ek,^{1,2} Matti Laine,^{1,4} Antti Revonsuo,^{1,5}
Mika Koivisto,^{1,2} and Heikki Hämäläinen^{1,2}

Test	Finland (n = 32)		Sweden (n = 32)		F	Sig. (non-corrected P-value)
	EMF OFF (ms)	EMF ON (ms)	EMF OFF (ms)	EMF ON (ms)		
SRT	281 (31)	281 (38)	278 (24)	278 (29)	0.001	.981
2CRT	416 (53)	426 (56)	417 (36)	417 (39)	1.734	.193
10CRT	668 (93)	669 (92)	683 (96)	676 (98)	0.260	.617
SUB	896 (125)	901 (121)	928 (133)	918 (142)	0.096	.758
Subtraction time	227 (79)	232 (96)	244 (94)	233 (100)	0.135	.715
VER	657 (147)	686 (152)	685 (193)	694 (184)	3.552	.064
Verification time	241 (108)	260 (116)	268 (173)	277 (167)	2.244	.139
VIG	515 (56)	515 (49)	494 (46)	502 (41)	0.959	.331
CON	394 (43)	397 (53)	400 (36)	414 (43)	2.782	.101
IN1	429 (74)	427 (70)	465 (78)	474 (73)	0.421	.519
IN2	427 (58)	429 (45)	439 (57)	447 (56)	0.636	.428
Stroop1	21 (37)	34 (48)	61 (68)	57 (43)	0.359	.551
Stroop2	20 (38)	35 (43)	32 (37)	31 (39)	1.010	.319

NOT REPLICATED !!!

Brief Communication

Psychomotor Performance is Not Influenced by Brief Repeated Exposures to Mobile Phones

G. Curcio,^{1,2*} E. Valentini,¹ F. Moroni,¹ M. Ferrara,³ L. De Gennaro,¹ and M. Bertini¹



NOT REPLICATED !!!

Task	Measure	Effect	Mean ± SE	<i>F</i>	df	<i>P</i>
SRTT	Speed ^a	Condition	ON 248.01 ± 9.43	2.10	1.23	0.16
			OFF 257.17 ± 9.89			
SFTT	Speed ^b	Condition	ON 2126.74 ± 125.23	0.56	1.23	0.16
			OFF 2248.06 ± 163.08			
	Accuracy ^c	Condition	ON 12.99 ± 0.83	1.56	1.23	0.23
			OFF 11.80 ± 0.85			



In conclusion: (1) cognition & behavior

Review

Systematic review and meta-analysis of
psychomotor effects of mobile phone
elect

Elia Val
Giusepr

BIO ELECTRO MAGNETICS



Review

Acute effects
emitted by r

 **frontiers**
in Public Health

Jun Zhang, Alexandre

First published: 20 A

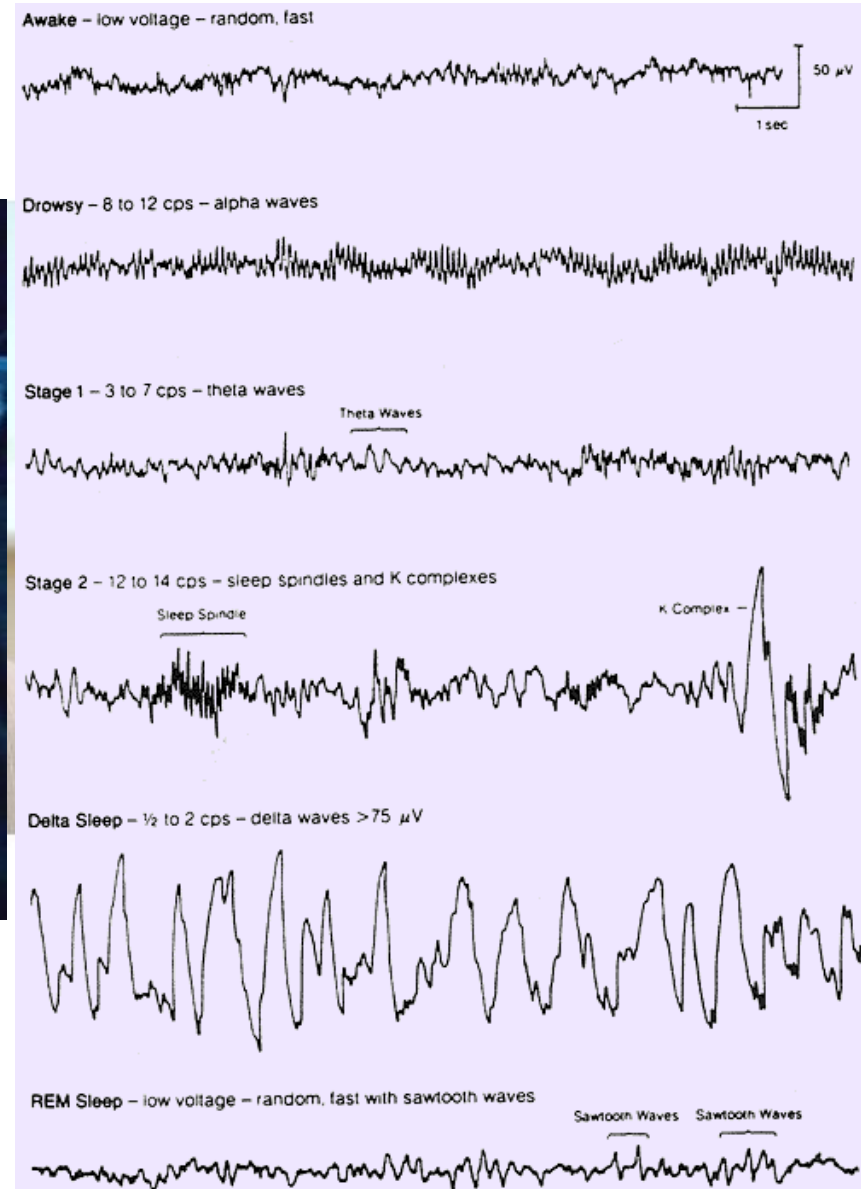
MINI REVIEW
published: 23 February 2018
doi: 10.3389/fpubh.2018.00042



Exposure to Mobile Phone-Emitted Electromagnetic Fields and Human Attention: No Evidence of a Causal Relationship

Giuseppe Curcio*

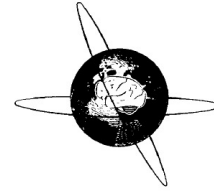
Brain functioning: waking & sleeping EEG activity



Brain functioning: waking EEG activity



Clinical Neurophysiology 113 (2002) 1623–1632

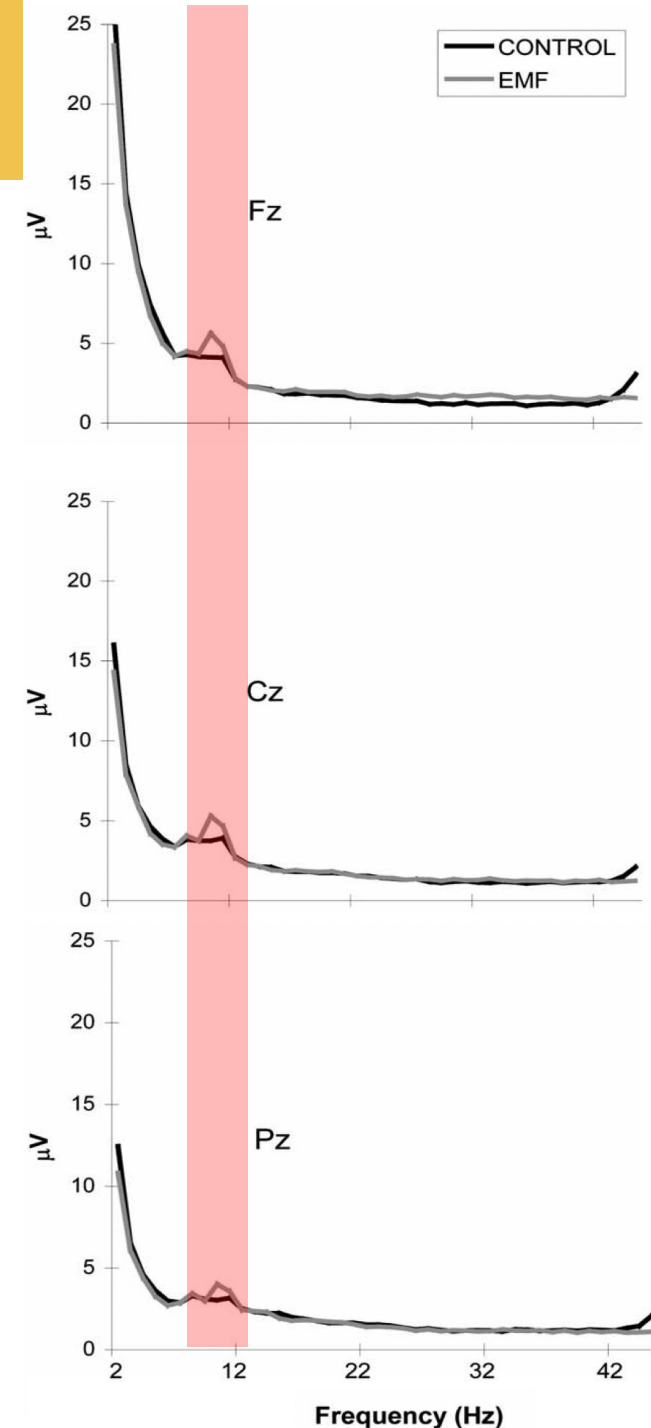
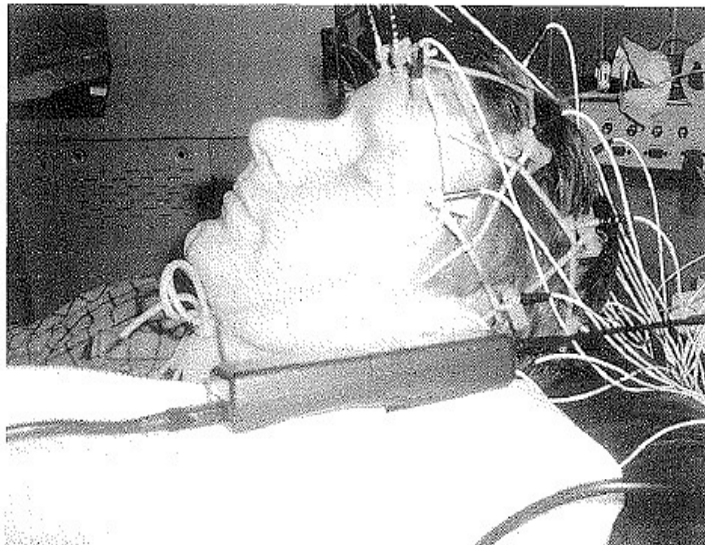


www.elsevier.com/locate/clinph

Acute mobile phone operation affects neural function in humans

Rodney J. Croft^{a,b,*}, Jody S. Chandler^a, Adrian P. Burgess^c, Robert J. Barry^a,
John D. Williams^d, Adam R. Clarke^a

Active MPs affect neural function in humans and do so as a function of exposure duration

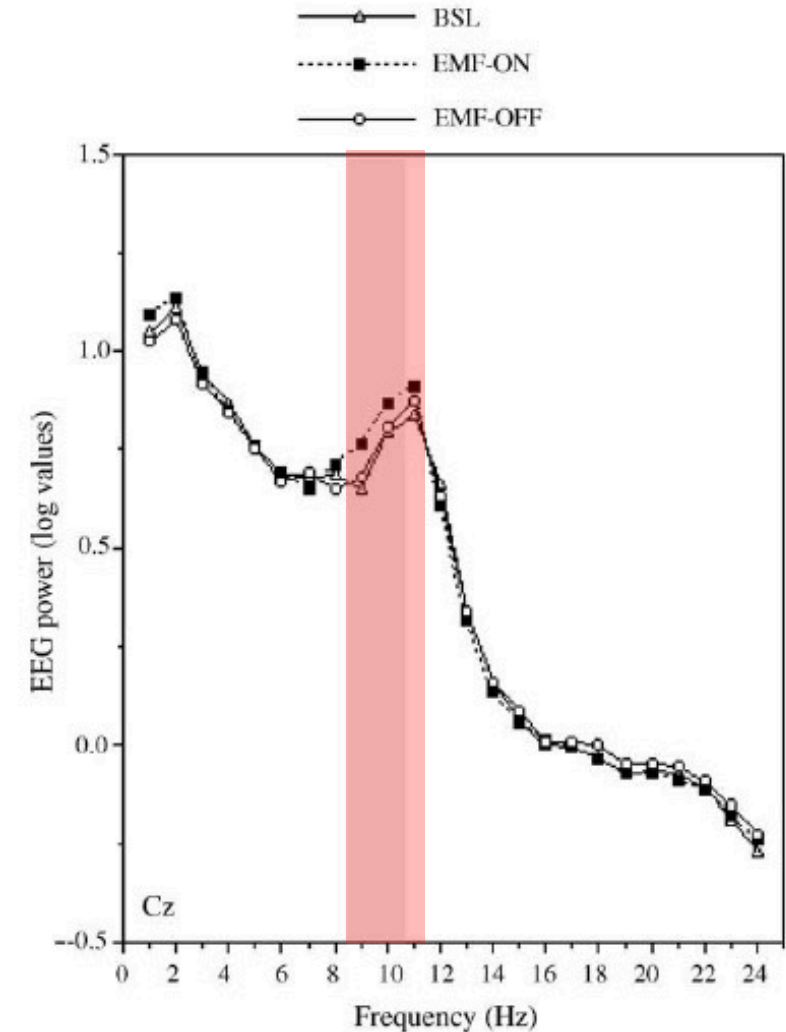


Is the brain influenced by a phone call? An EEG study of resting wakefulness

G. Curcio ^{a,*}, M. Ferrara ^b, F. Moroni ^a, G. D’Inzeo ^c,
M. Bertini ^a, L. De Gennaro ^a



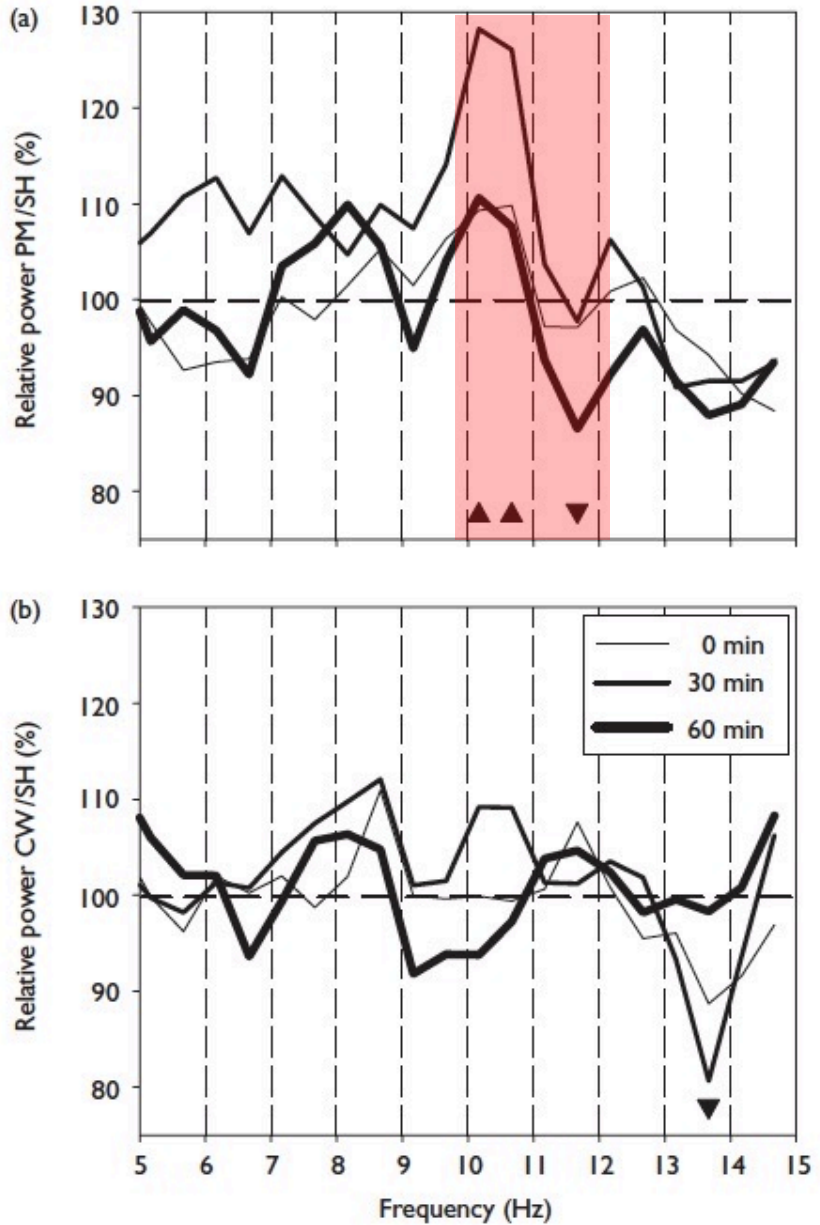
Alpha band influenced by
real exposure



Pulsed radio frequency radiation affects cognitive performance and the waking electroencephalogram

Sabine J. Regel^a, Julie M. Gottselig^a, Jürgen Schuderer^d, Gilberte Tinguely^a, Julia V. Rétey^a, Niels Kuster^d, Hans-Peter Landolt^{a,b,c} and Peter Achermann^{a,b,c}

Increased spectral power in the waking electroencephalogram in the alpha range



In conclusion: (2) waking EEG activity

Bioelectromagnetics 28:415–432 (2007)



Neurop
Ele

Research Article

The Effect of GSM Electromagnetic Field Exposure on the Waking Electroencephalogram: A Meta-Analysis

E. Valentini,¹ G. Ci

Environmental Research 175 (2019) 274–286

Anna Dalecki, Adam V



ELSEVIER

Contents lists available at [ScienceDirect](#)

Environmental Research

journal homepage: www.elsevier.com/locate/envres



First published: 12 Apr

Review article

Effect of mobile phone radiofrequency signal on the alpha rhythm of human waking EEG: A review

Jasmina Wallace^{a,b}, Brahim Selmaoui^{a,b,*}



Brain functioning: sleep EEG activity

Neuropsychobiology

Pharmacoelectroencephalography

Original Paper

Neuropsychobiology 1996;33:41-47

Klaus Mann
Joachim Rösclike

Department of Psychiatry, University of
Mainz, Germany

Effects of Pulsed High-Frequency Electromagnetic Fields on Human Sleep

After exposure sleep latency
and REM sleep percentage
were reduced,
and all frequency bands
resulted increased

Table 1. Classical sleep EEG parameters (mean \pm standard deviation of 12 subjects)

	Without field	With field
Sleep onset latency, min	12.25 \pm 5.96	9.50** \pm 4.44
Total sleep time, min	470.04 \pm 14.11	473.38 \pm 12.80
Sleep efficiency index, %	0.95 \pm 0.03	0.95 \pm 0.03
Number of awakenings	5.17 \pm 5.51	4.58 \pm 2.61
Awake, %SPT	2.99 \pm 3.45	2.95 \pm 2.71
Stage I, %SPT	9.22 \pm 2.20	10.22 \pm 3.06
Stage II, %SPT	52.98 \pm 5.33	54.14 \pm 7.03
Slow wave sleep, %SPT	15.70 \pm 3.30	16.69 \pm 5.86
REM, %SPT	17.07 \pm 3.23	13.91* \pm 2.88
REM latency, min	84.96 \pm 22.69	93.17 \pm 27.87

SPT = Sleep period time. * $p < 0.05$; ** $p < 0.005$.

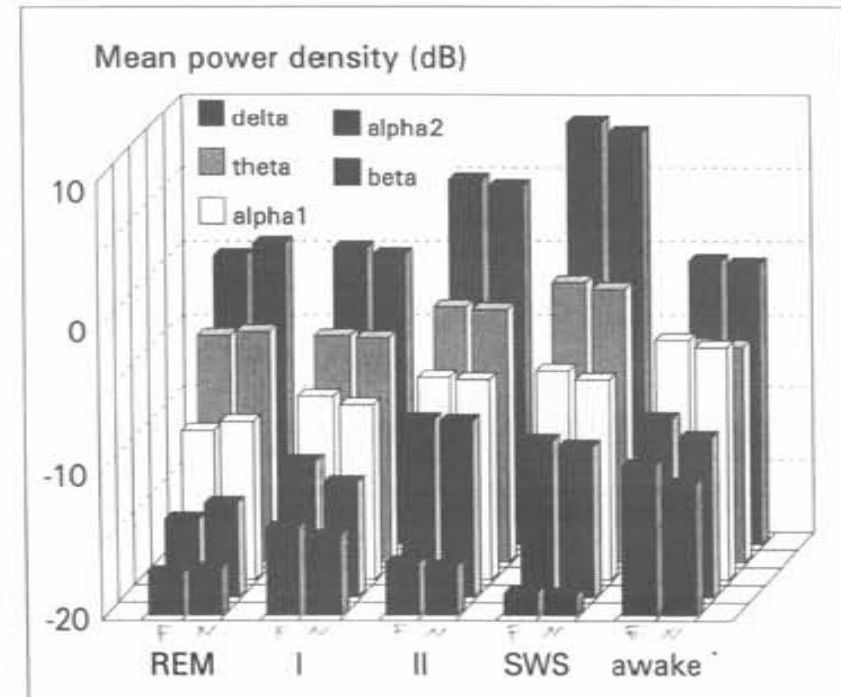
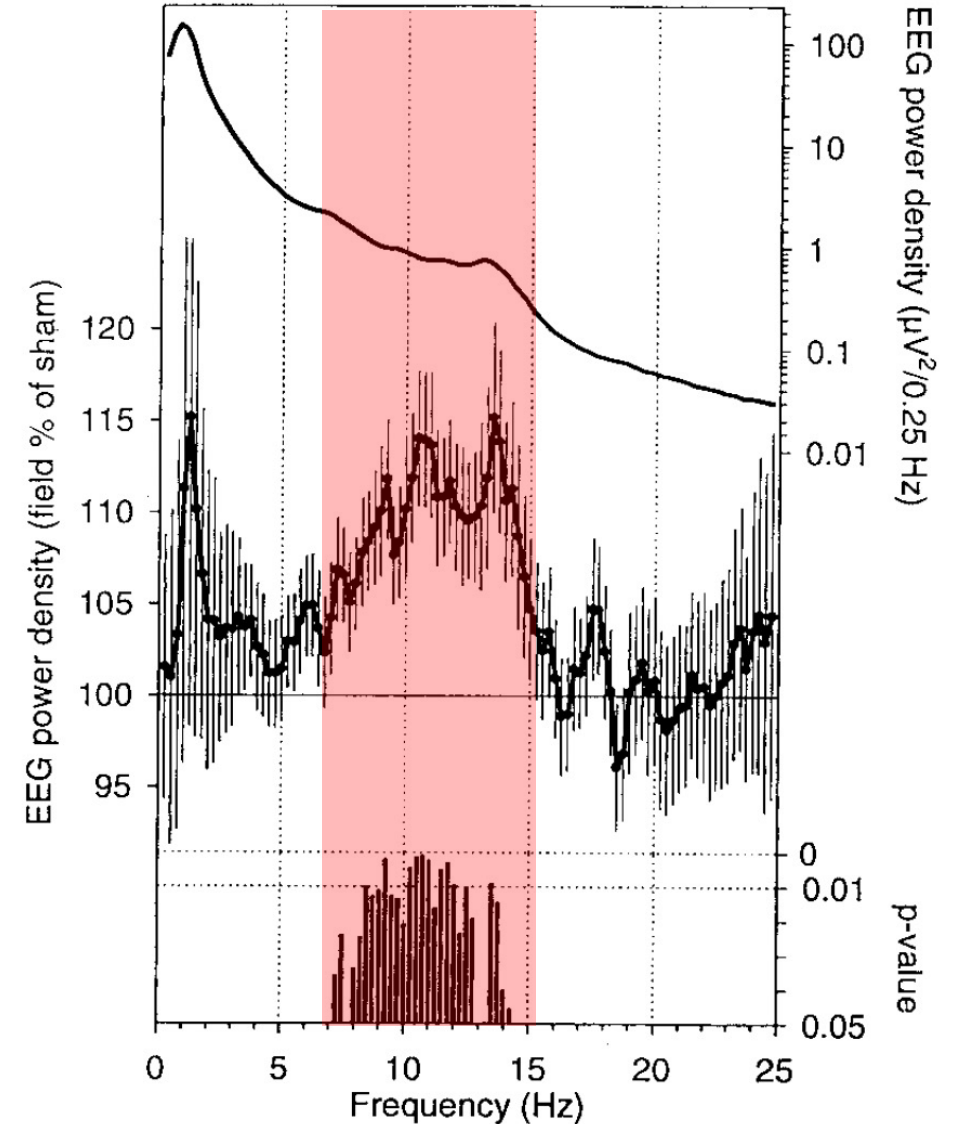


Fig. 1. Mean power density (dB) of the averaged power spectra of different sleep stages in the given frequency ranges. For definition of frequency bands, see text. Mean of 12 subjects (0 dB corresponds to 1 (μV)²/Hz). Left columns: without field; right columns: with field.

Pulsed high-frequency electromagnetic field affects human sleep and sleep electroencephalogram

Alexander A. Borbély*, Reto Huber, Thomas Graf, Barbara Fuchs, Eva Gallmann, Peter Achermann

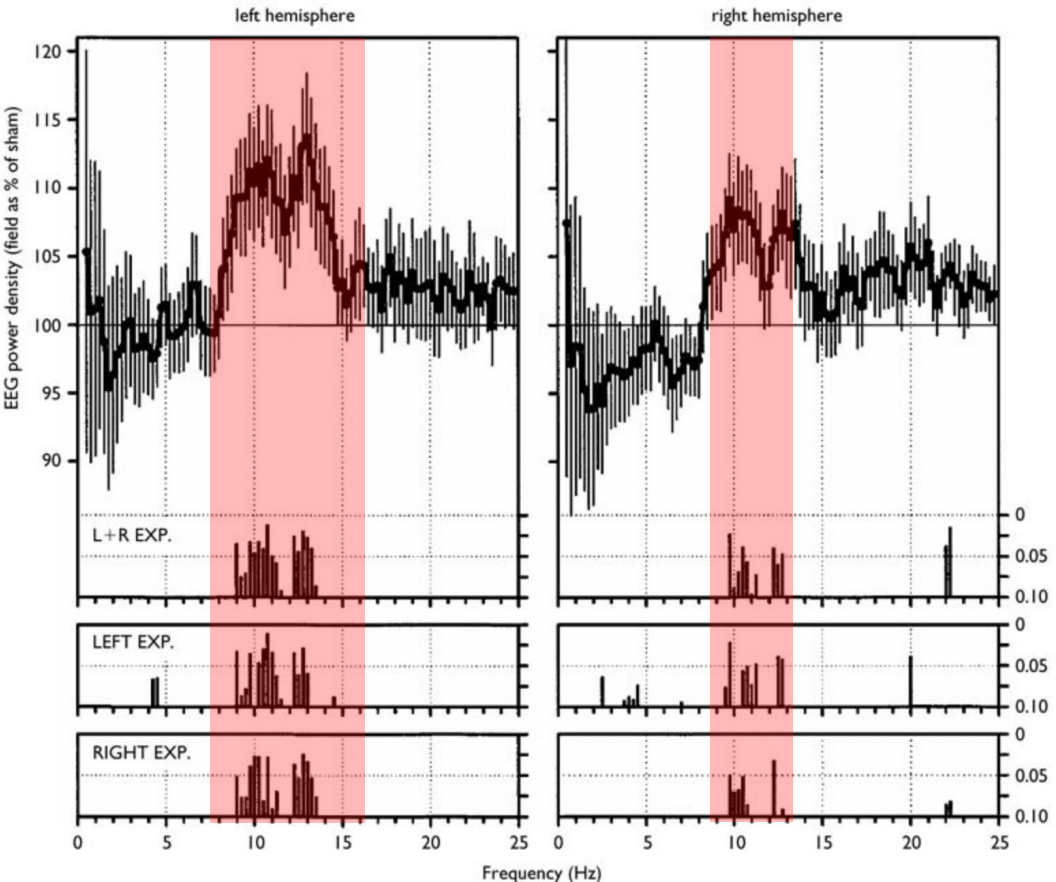
Waking after sleep onset was reduced and spectral power in the alpha and sleep spindle ranges increased under exposure.



Electromagnetic fields, such as those from mobile phones, alter regional cerebral blood flow and sleep and waking EEG

R. HUBER¹, V. TREYER², A. A. BORBÉLY¹, J. SCHUDERER³,
J. M. GOTTSELIG¹, H.-P. LANDOLT¹, E. WERTH¹, T. BERTHOLD²,
N. KUSTER³, A. BUCK² and P. ACHERMANN¹

Alpha and sigma EEG
resulted enhanced
in the first 30
minutes of NREM sleep



In conclusion: (3) sleeping EEG activity

The Routledge
International Handbook
of Psychobiology

5

Are there hidden dangers to mobile phone use?

A psychobiologic



ELSEVIER

Rodney J. Croft, Giuseppe Curcio, and



Sleep Medicine Reviews

Volume 47, October 2019, Pages 28-38



Theoretical Review

The potential for impact of man-made super low and extremely low frequency electromagnetic fields on sleep

Maurice M. Ohayon ^a  , Victor Stolc ^b, Friedemann T. Freund ^c, Cristina Milesi ^d
, Shannon S. Sullivan ^e

Open points for future research

- Other type of signals (e.g., radio-base stations, 5G)
- Environmental exposure
- Cumulative effects (from chronic exposure)
- Individual sensitivity (e.g., Idiopathic Environmental Intolerance attributed to Electromagnetic Fields: IEI-EMF)
- Particular vulnerability of some groups of people (e.g., elderly, children and adolescents, epileptic patients)

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<https://labscoc.wordpress.com/>