New human experimental studies on HF

Gunnhild Oftedal
Norwegian University of Science and Technology (NTNU)

New studies: Papers published in 2011–2015

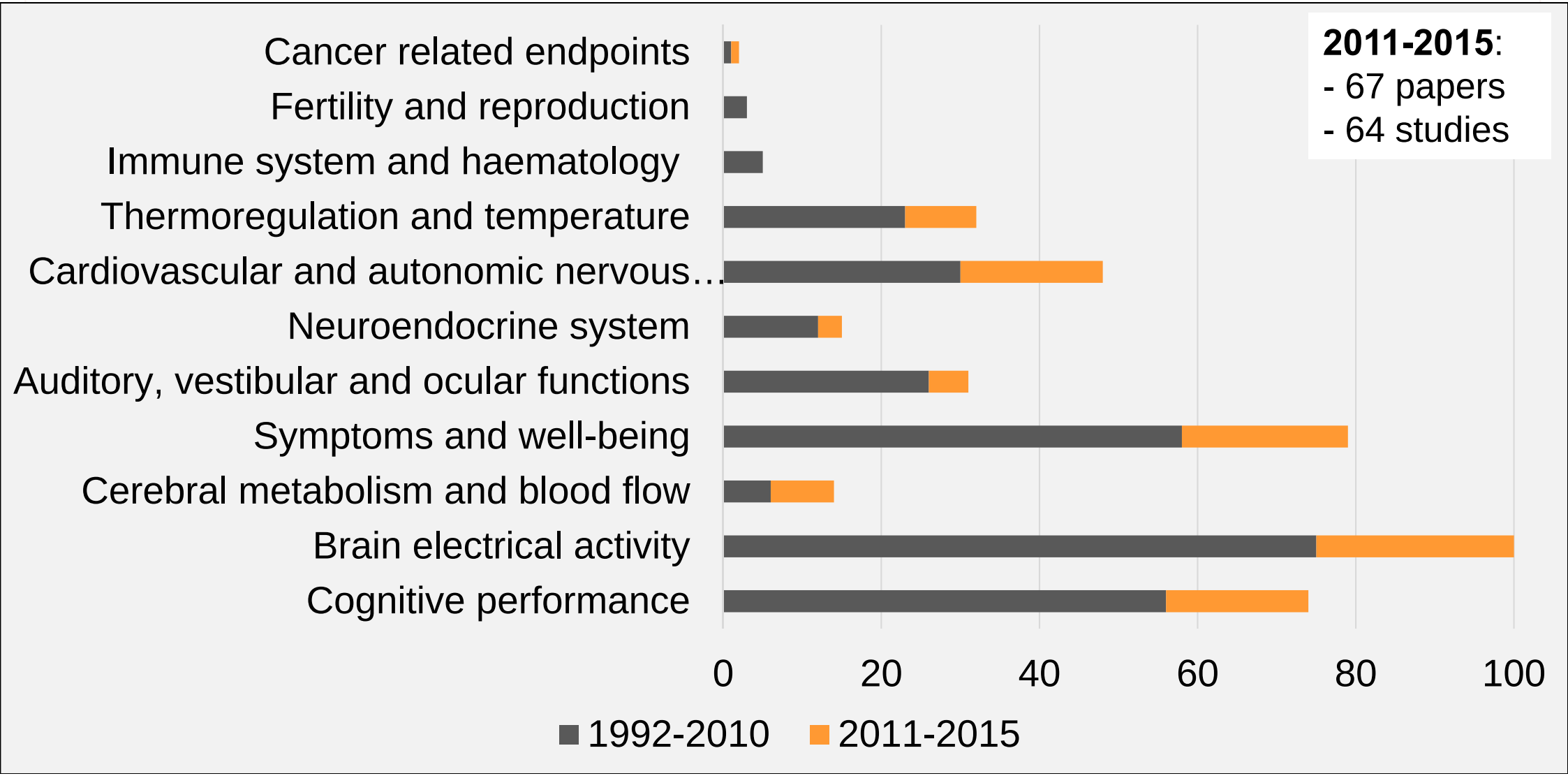
Searches and reviews mostly done as part of the preparation of the **WHO's Environmental Health Criteria for radio frequency electromagnetic fields**

in co-work with:

- Brahim Selmaoui, France
- G. James Rubin, UK
- Giuseppe Curcio, Italy
- Rene de Sezé, France
- Sarah Loughran, Australia

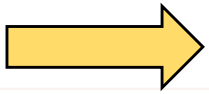
Human HF studies 1992–2010 & 2011–2015

Peer-reviewed journal papers



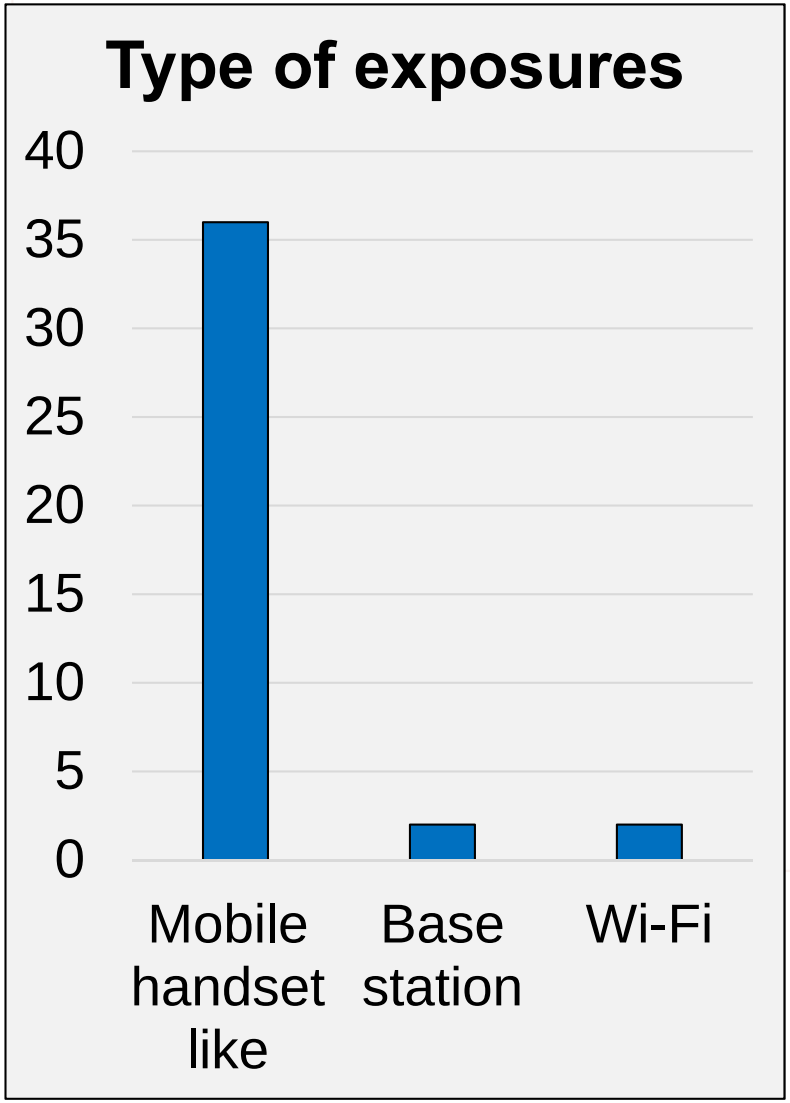
Inclusion quality criteria

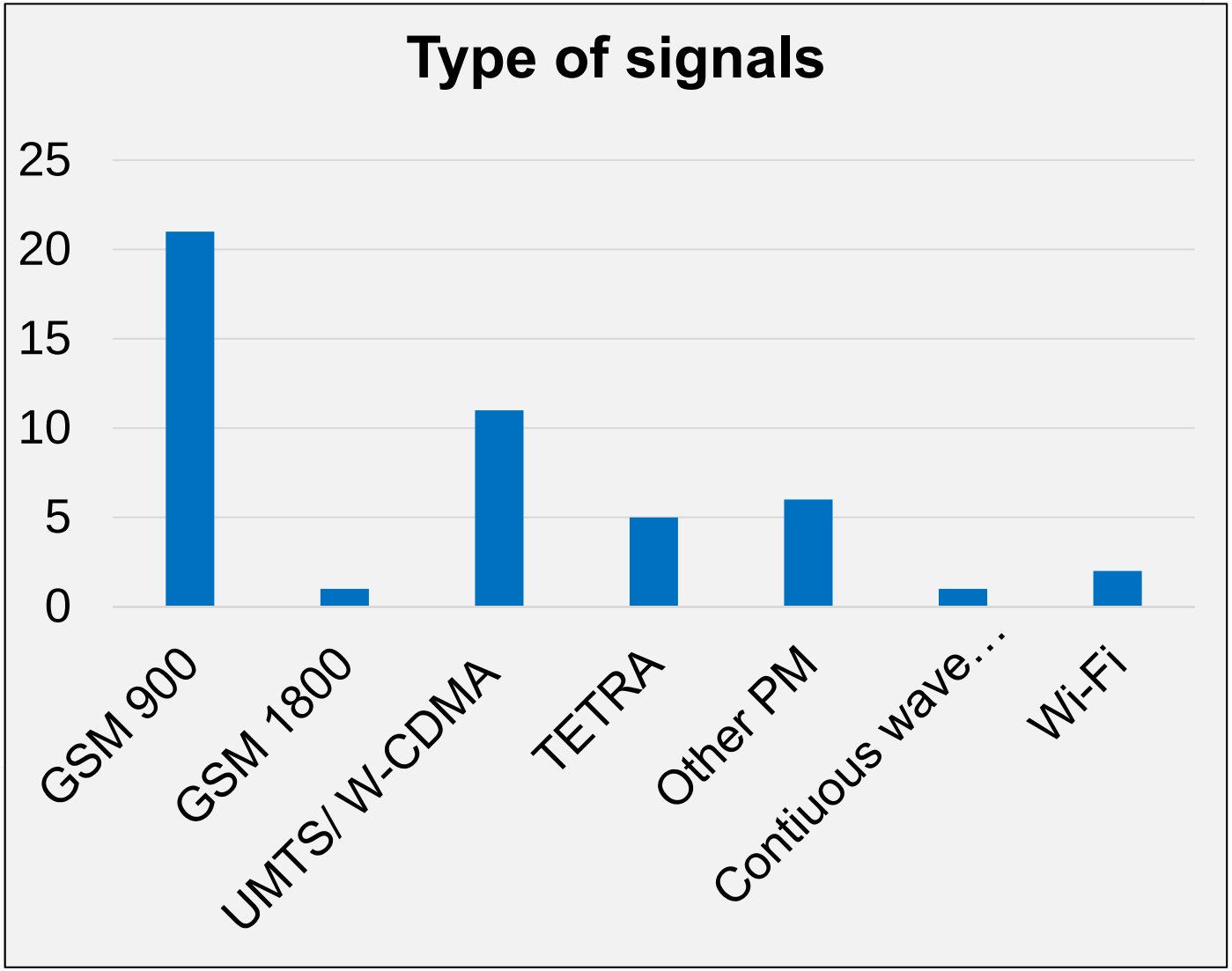
- Blinded to the participants
- At least two exposure levels (one could be a sham)
- Exposure levels sufficiently controlled and documented
- Exposures not given in fixed order
- Relevant statistical analysis



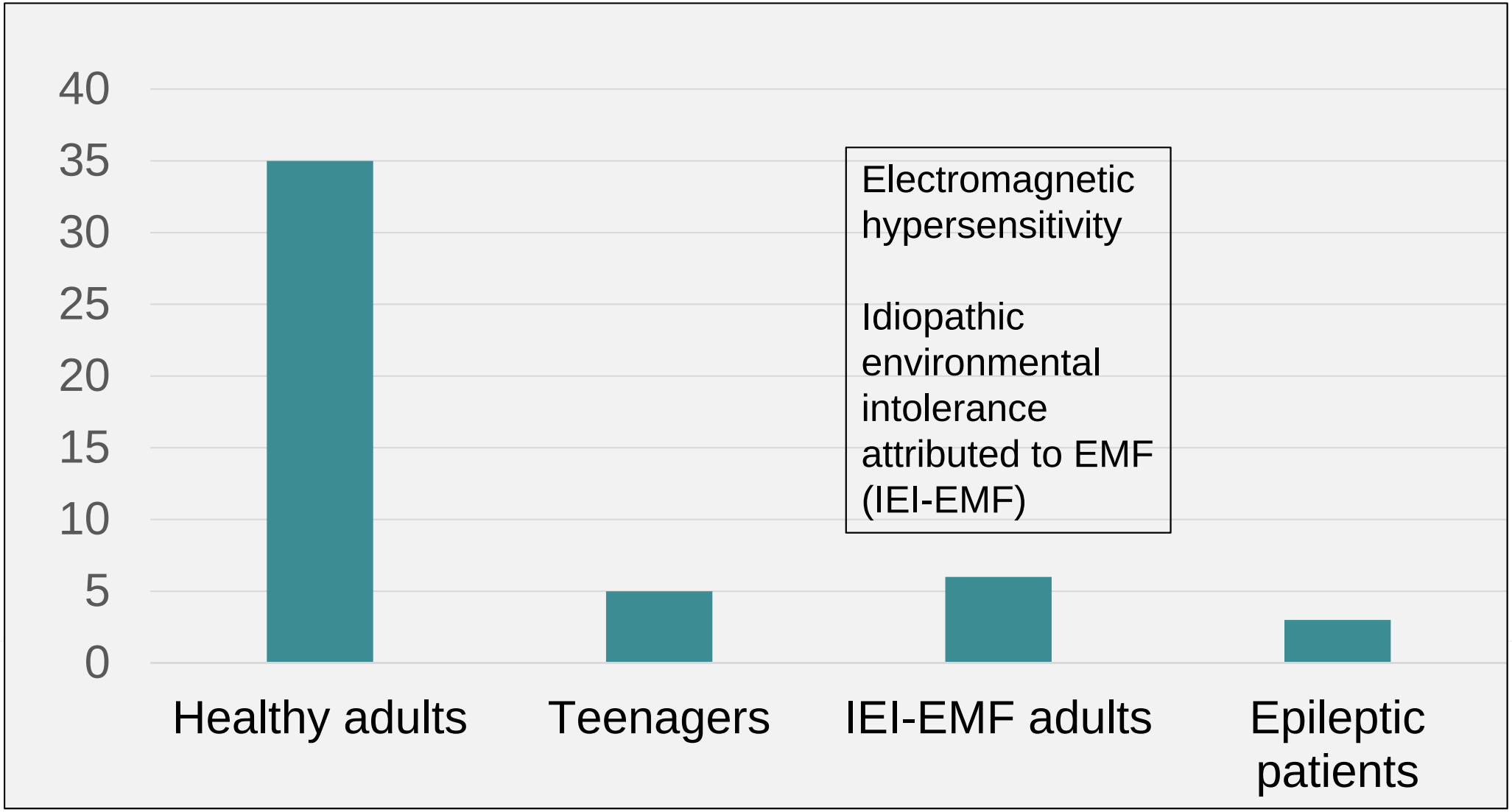
40 included studies (71% of total)

Exposures applied





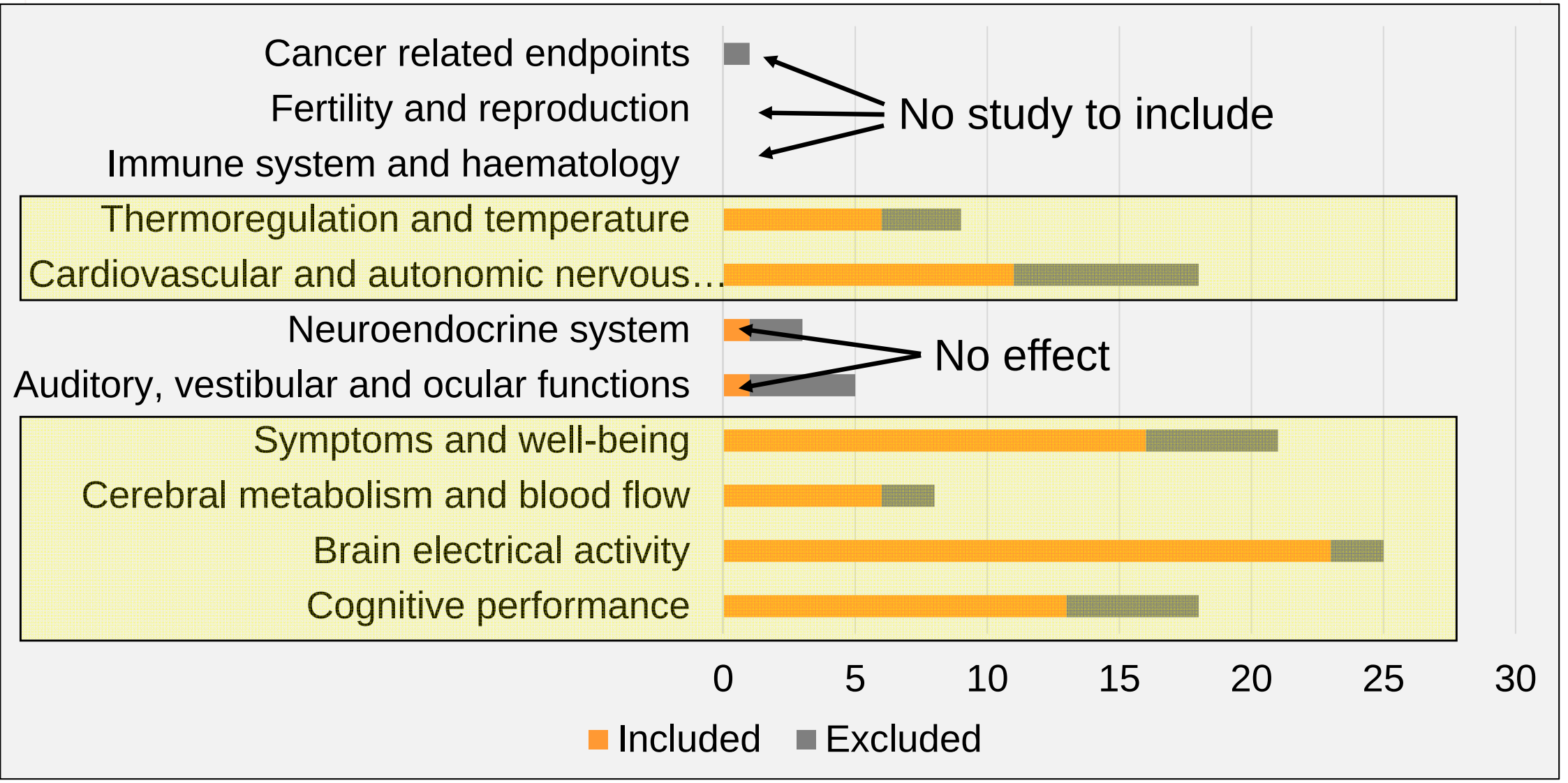
Study groups



GO1

ICNIRP
INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION

Number of included and excluded studies 2011-2015

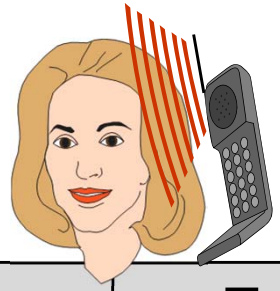


Assessment of included studies

- Systematic **differences** between studies/conditions indicating effect and those that did not?
- **Consistencies** between studies/conditions indicating effects?

  - Outcome
  - Exposure
  - Number of participants
  - Other factors of importance for outcome

Temperatures

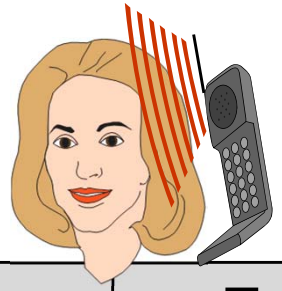


Mobile phone handset like exposures of head

No. of studies	Participants (n)	Frequency (MHz)	SAR_{10g} (W/kg)	Exposure time (min)	Temperatures	
					Face skin	Ear canal
2[1]	**Healthy adults** (13, 15)	900	0.7	30	< ~ 0.2 °C	No effect
			0.7, 1.0	5	No effect	< 0.04 °C
1[2]	(15)	385	1.5	30	No effect	-
		385	**6.0**	30	+ ~ 0.8 °C	-
2[3]	(20, 29)	900	0.49	20	No effect	-
1[4]	**Adolescents** (23)	900	2.0	15	No effect	-

1: Kwon et al. (2011, 2012b);
2: Dorn et al. (2014)
3: Ghosn et al. (2012), Loos et al (2013)
4. Lindholm et al. (2011)

Temperatures



Mobile phone handset like exposures of head

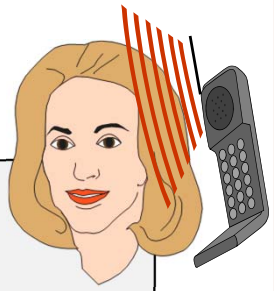
No. of studies	Participants (n)	Frequency	SAR_{10g}	Exposure	Temperatures	
					skin	Ear canal
2[1]						effect
2[3]						
1[4]	**Adolescent** (23)				effect	No effect

SAR ≤ 2 W/kg: no consistent measurable increase in skin and ear canal temperature

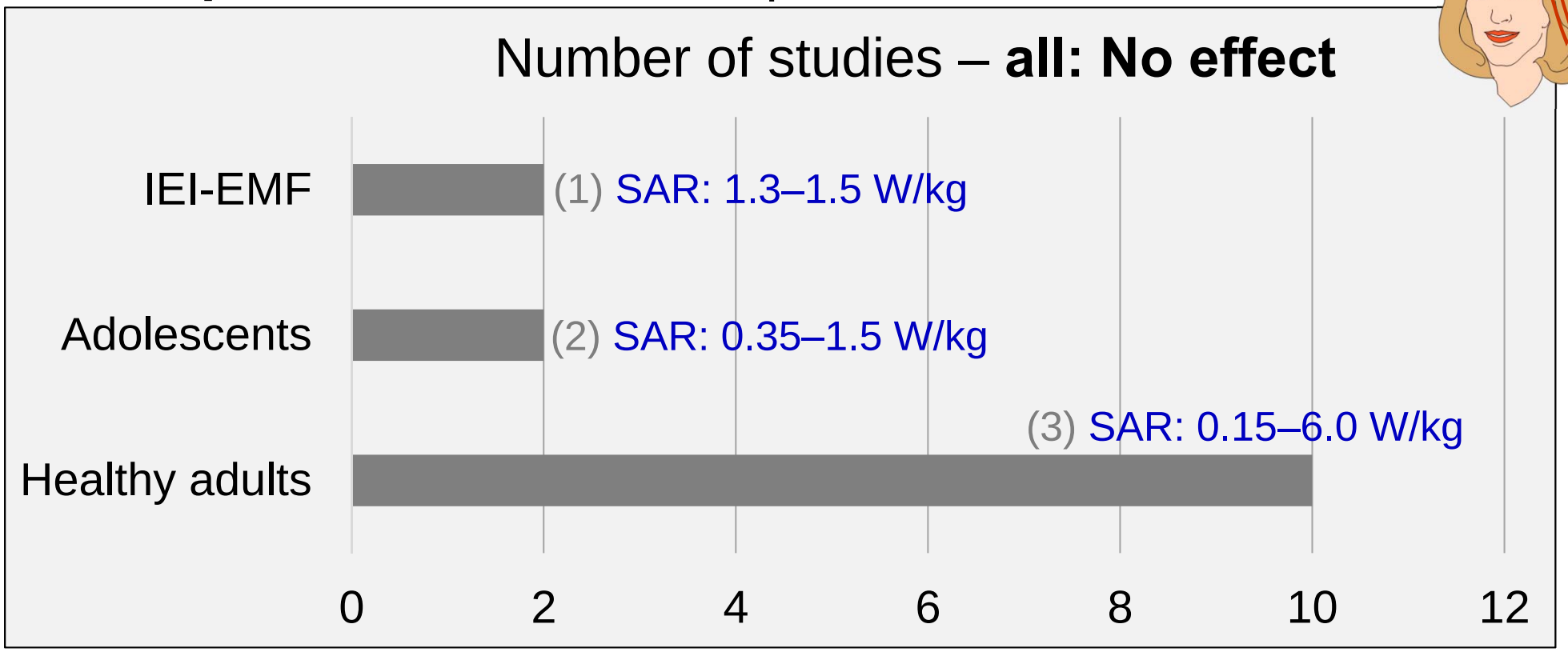
SAR = 6 W/kg: + 0.8 °C skin temperature (plausible, but one study only)

1: Kwon et al. (2011, 2012b);
2: Dorn et al. (2014)
3: Ghosn et al. (2012), Loos et al (2013)
4. Lindholm et al. (2011)

Ability to perceive exposure

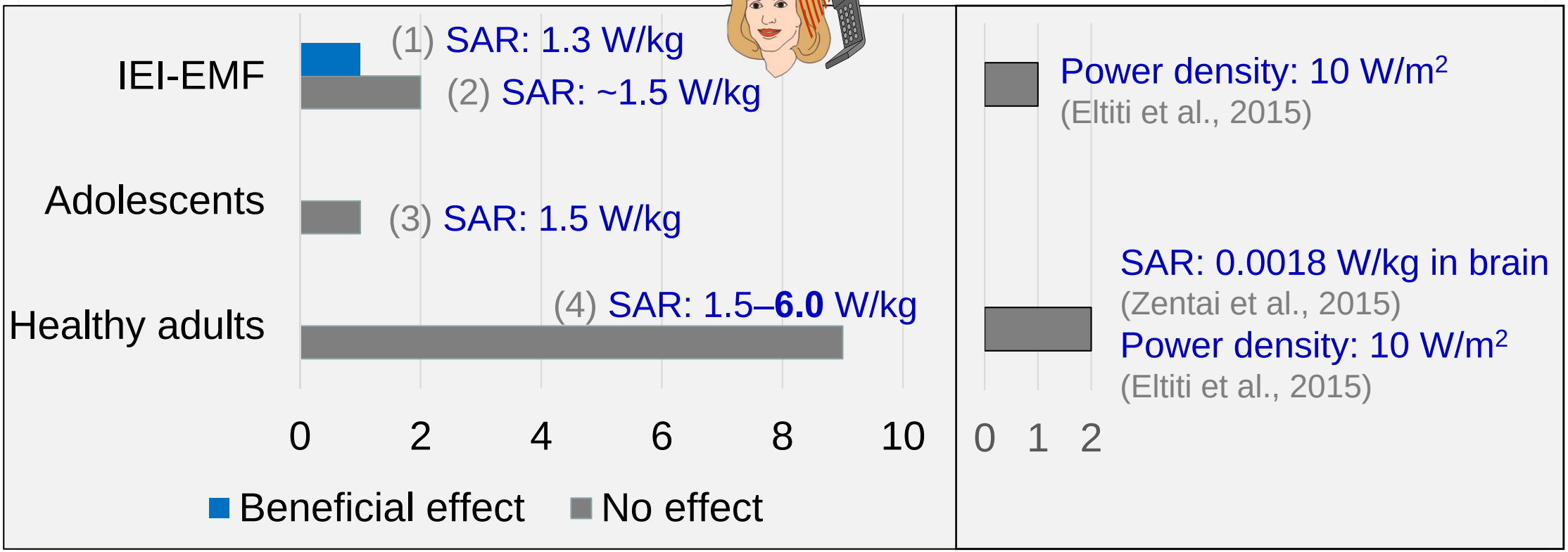


Mobile phone handset like exposures



1: Nieto-Hernandez et al. 2011, Kwon et al. 2012a. 2: Loughran et al. (2013), Choi et al. (2014)
3: Schmid et al. (2012a,b), Spichtig et al. (2012), Lustenberger et al. (2013), Nakatani-Enomoto et al. (2013), Choi et al. (2014), Nieto-Hernandez et al. (2011), Kwon et al. (2012a), Dorn et al. (2014), Sauter et al. (2015).

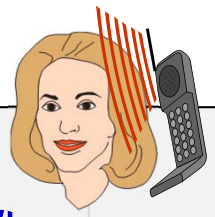
Symptoms and well-being



1: *Nieto-Hernandez et al. (2011) 2: Lowden et al. (2011), Kwon et al. (2012) 3: Choi et al. (2014)
4: Lowden et al. (2011), Schmid et al. (2012a,b), Spichtig et al. (2012), Lustenberger et al. (2013), Nakatani-Enomoto et al. (2013), Choi et al. (2014), Sauter et al. (2015), Nieto-Hernandez et al. (2011), Kwon et al. (2012a)

Symptoms and well-being

Mobile phone handset-like



Base station, Wi-Fi

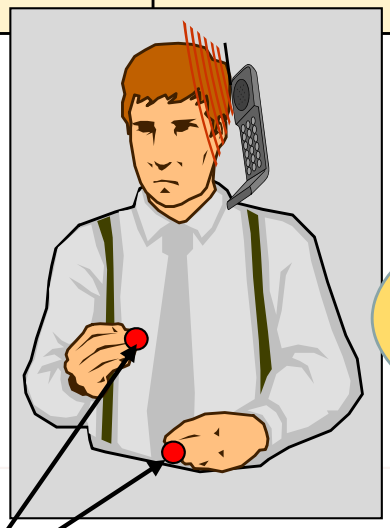
1: *Nieto-Hernandez et al. (2011) 2: Lowden et al. (2011), Kwon et al. (2012) 3: Choi et al. (2014)
4: Lowden et al. (2011), Schmid et al. (2012a,b), Spichtig et al. (2012), Lustenberger et al. (2013), Nakatani-Enomoto et al. (2013), Choi et al. (2014), Sauter et al. (2015), Nieto-Hernandez et al. (2011), Kwon et al. (2012a)

Vecsei et al. (2013)

ICNIRP
INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION

Effect on pain perception?

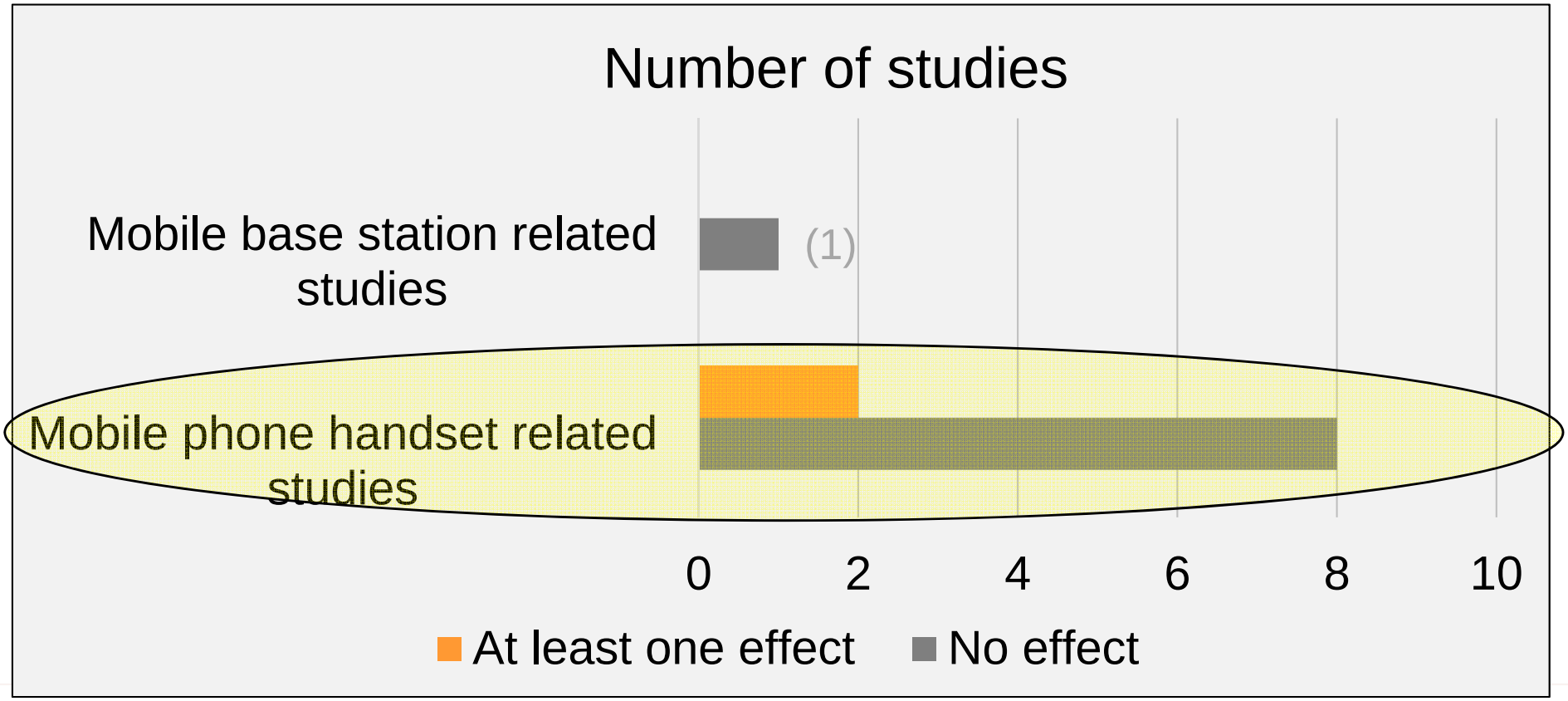
Paper	Participants (n)	Type of exposure	Frequency SAR_{10g}	Finding
Vecsei et al. (2013)	**Healthy adults** (20)	UMTS	1947 MHz 0.73 W/kg	**Less increase in threshold for thermal pain** from one trial to the next



Heating until pain, repeated trials

Replication needed

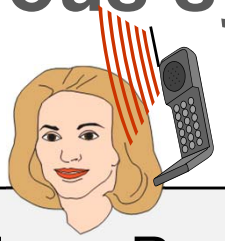
Cardiovascular and autonomic nervous systems

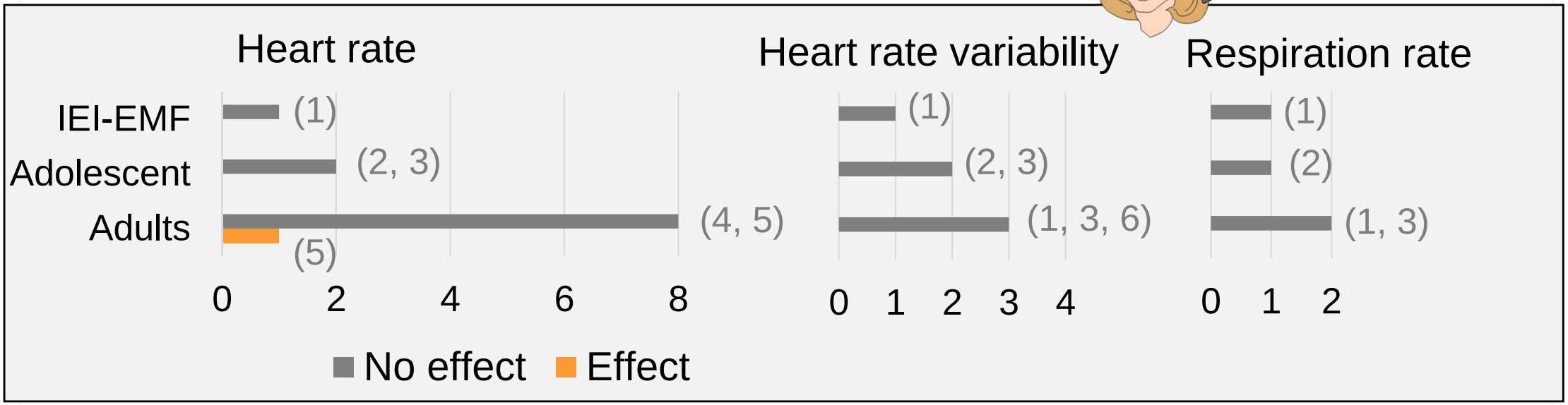


1: Wallace et al. (2012)

Cardiovascular and autonomic nervous systems

Mobile phone handset like exposures of head



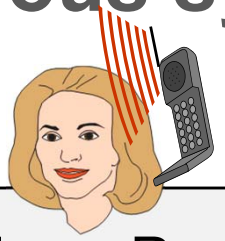


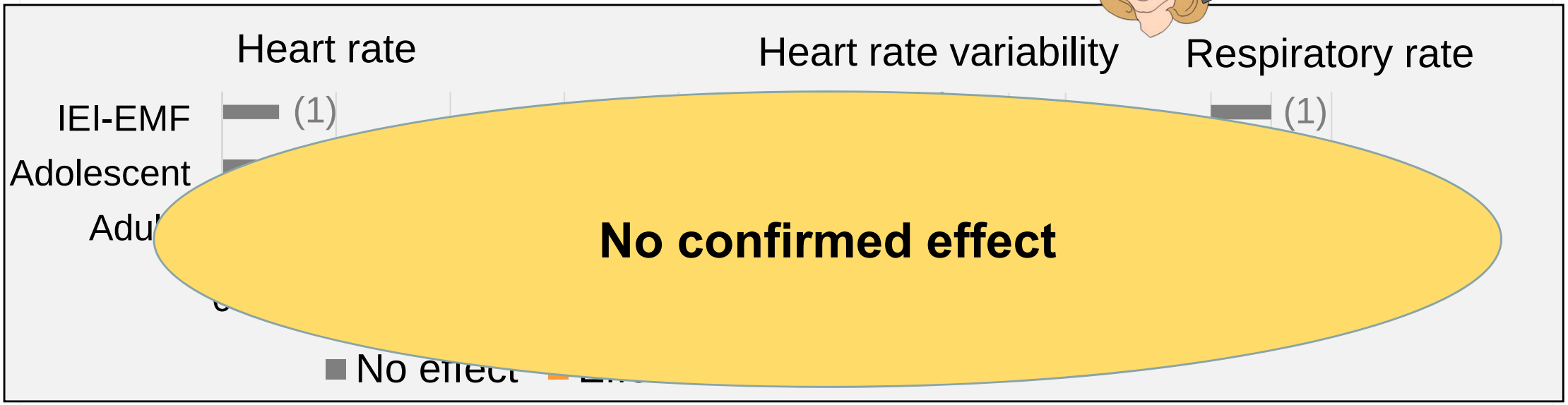
1: Kwon et al. (2012a) 2: Lindholm et al. (2011) 3: Choi et al. (2014)
4: Kwon et al. (2012a), Schmid et al. (2012a,b), Ghosn et al. (2012, 2015), Choi et al. (2014)
5: Spichtig et al. (2012) 6: Parazzini et al. (2013)

Loos et al. (2015): Increased skin blood flow at exposed side.

Cardiovascular and autonomic nervous systems

Mobile phone handset like exposures of head





No confirmed effect

1: Kwon et al. (2012a) 2: Lindholm et al. (2011) 3: Choi et al. (2014)
4: Kwon et al. (2012a), Schmid et al. (2012a,b), Ghosn et al. (2012, 2015), Choi et al. (2014)
5: Spichtig et al. (2012) 6: Parazzini et al. (2013)

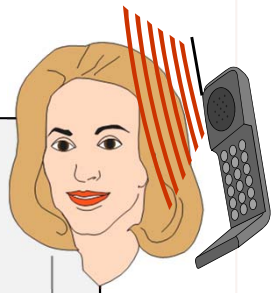
Loos et al. (2015): Increased skin blood flow at exposed side

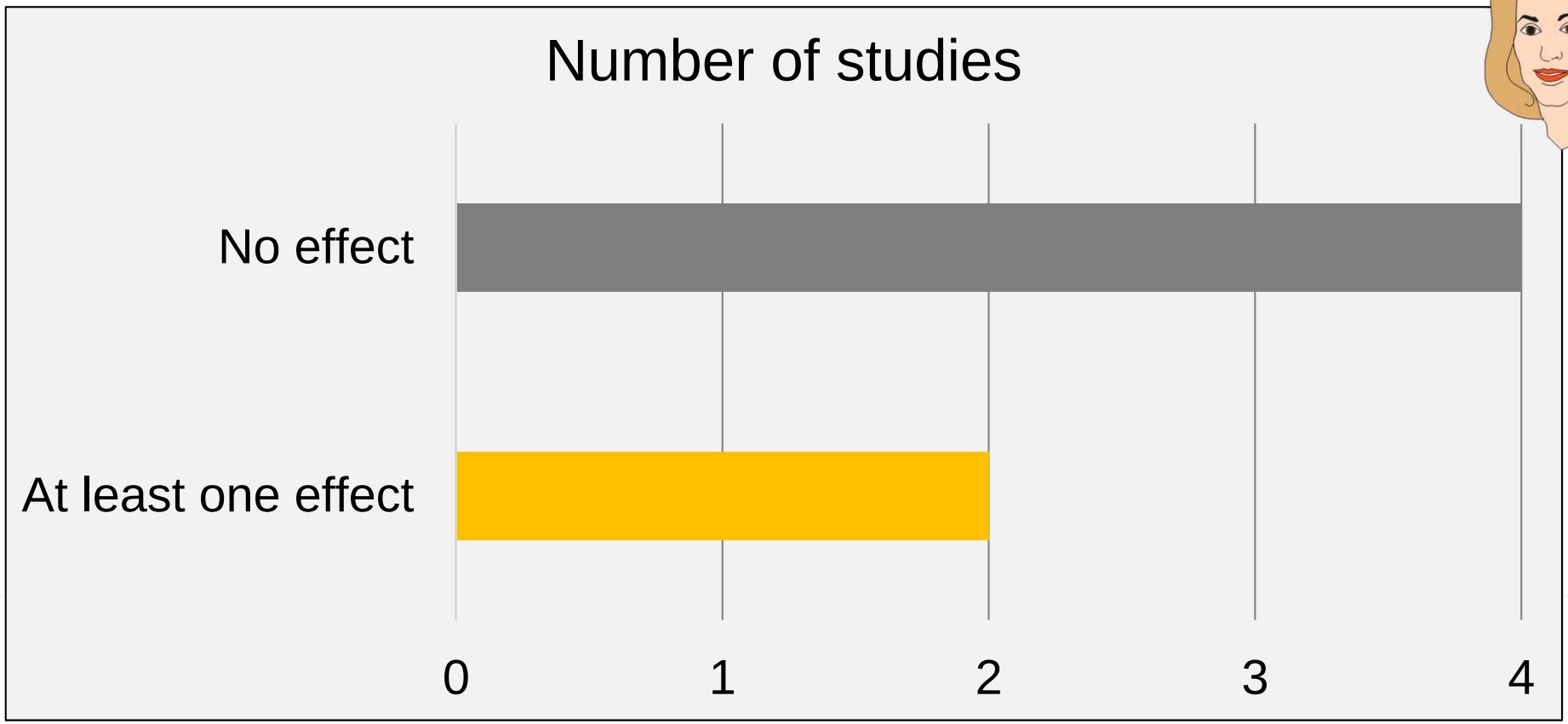
Replication needed

Cerebral metabolism and blood flow

(Blood flow increases with increasing metabolism)

All: Mobile phone handset like exposures of head





Cerebral metabolism and blood flow

Ref	n	System, frequency (MHz)	SAR_{10g} (W/kg)	Time (min)	Method	Finding
Kwon et al. (2011)	13	GSM 902.4	0.7	30	PET	**Reduced** blood flow at exposed side
Kwon et al. (2012b)	15	GSM 902.4	0.7–1.0	5	PET	No effect
Curcio et al. (2012)	12	GSM 902.4	0.5	45	fMRI	No effect
Ghosn et al. (2012)	29	GSM 900	0.5	20	Doppler sonography	No effect
Spichtig et al. (2012)	16	UMTS 1900	0.18, 1.8	22 (20 s on, 60 s off)	Near infrared imaging	**Reduced** metabolism: < 80 s: at 0.18 W/kg > 80 s: at 0.18, 1.8 W/kg
Adolescents						
Lindholm et al. (2011)	23	GSM 902.4	2.0	15	Near infrared imaging	No effect

Cerebral metabolism and blood flow

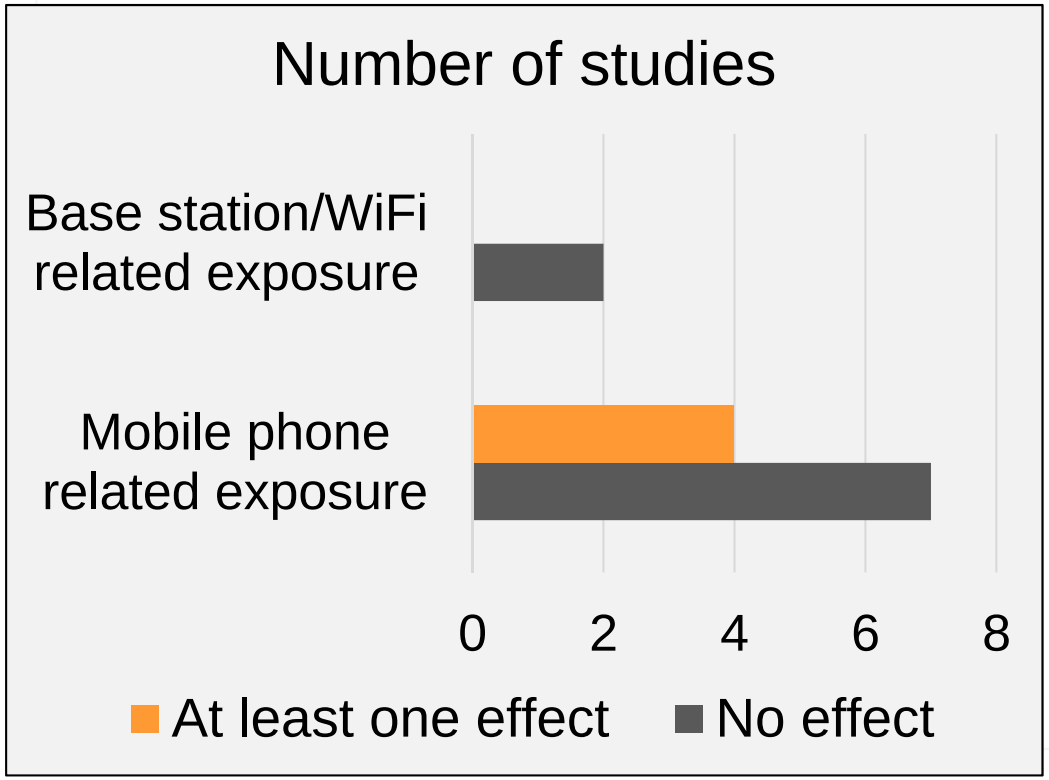
Ref	n	System, frequency (MHz)	SAR_{10g} (W/kg)	Time (min)	Method	Finding
Kwon et al. (2011)	13	GSM 902.4	0.7	30	PET	**Reduced** blood flow at exposed side
Kwon et al. (2012b)	15					
Curci (20						
Gh (201						
Spichtig e (2012)						abolism: at 0.18 W/kg > 80 s: at 0.18, 1.8 W/kg
Adolescents						
Lindholm et al. (2011)	23	GSM 902.4	2.0	15	Near infrared imaging	No effect

Reasons for indicated effects vs. no effects are not sufficiently clear

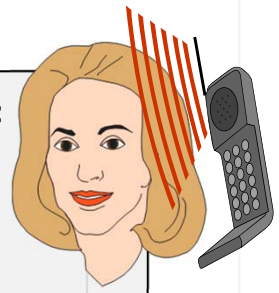
Further systematic search for factors of importance for potential effects is needed

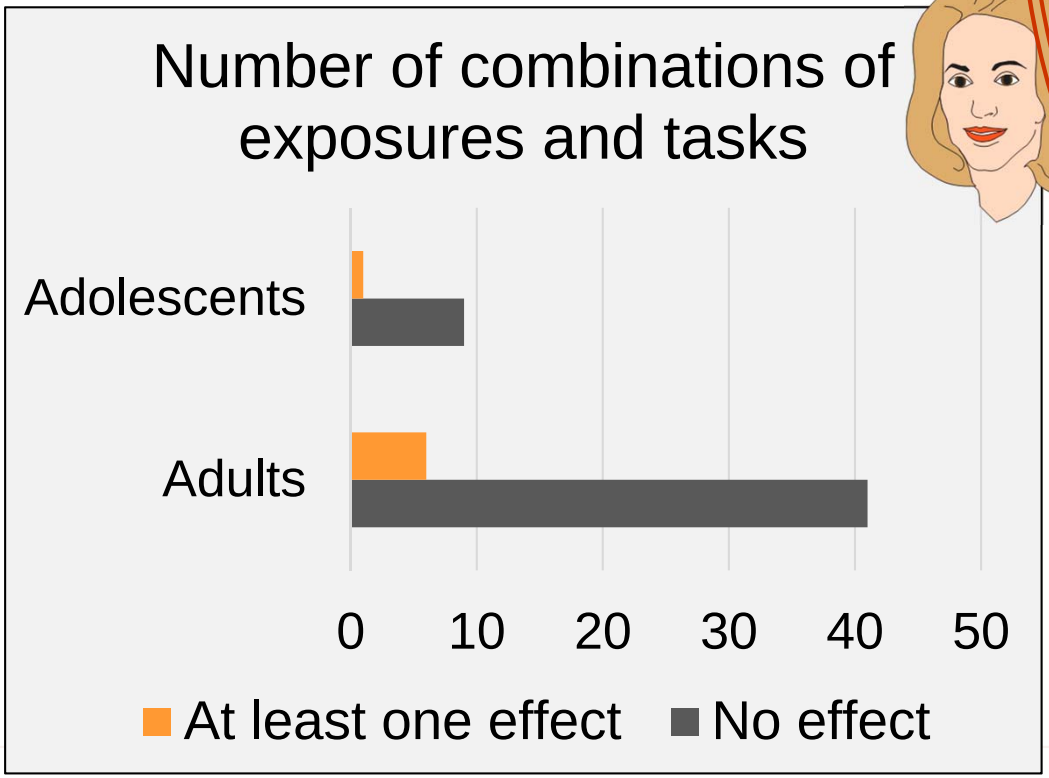
Cognitive performance

All studies



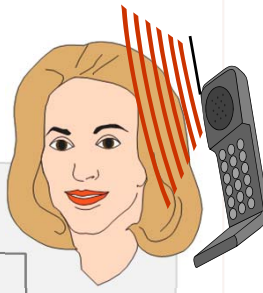
Mobile phone handset related studies

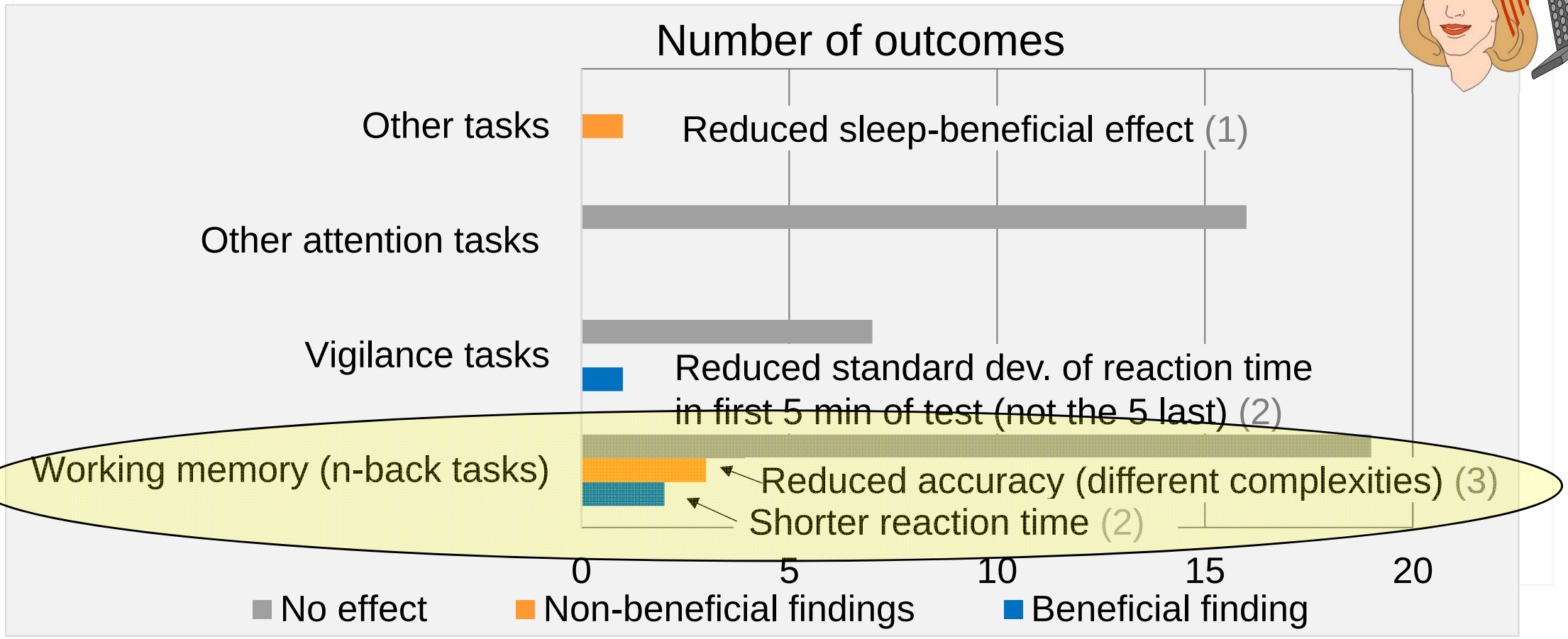




Cognitive performance

Consistencies in findings?

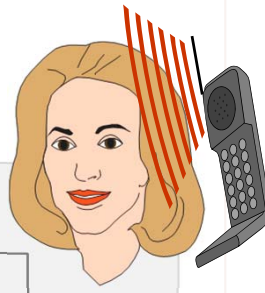




1. Lustenberger et al. (2013)
2. Sauter et al. (2015)
3. Leung et al. (2011), Schmid et al. (2012a), Sauter et al. (2015)

Cognitive performance

Consistencies in findings?

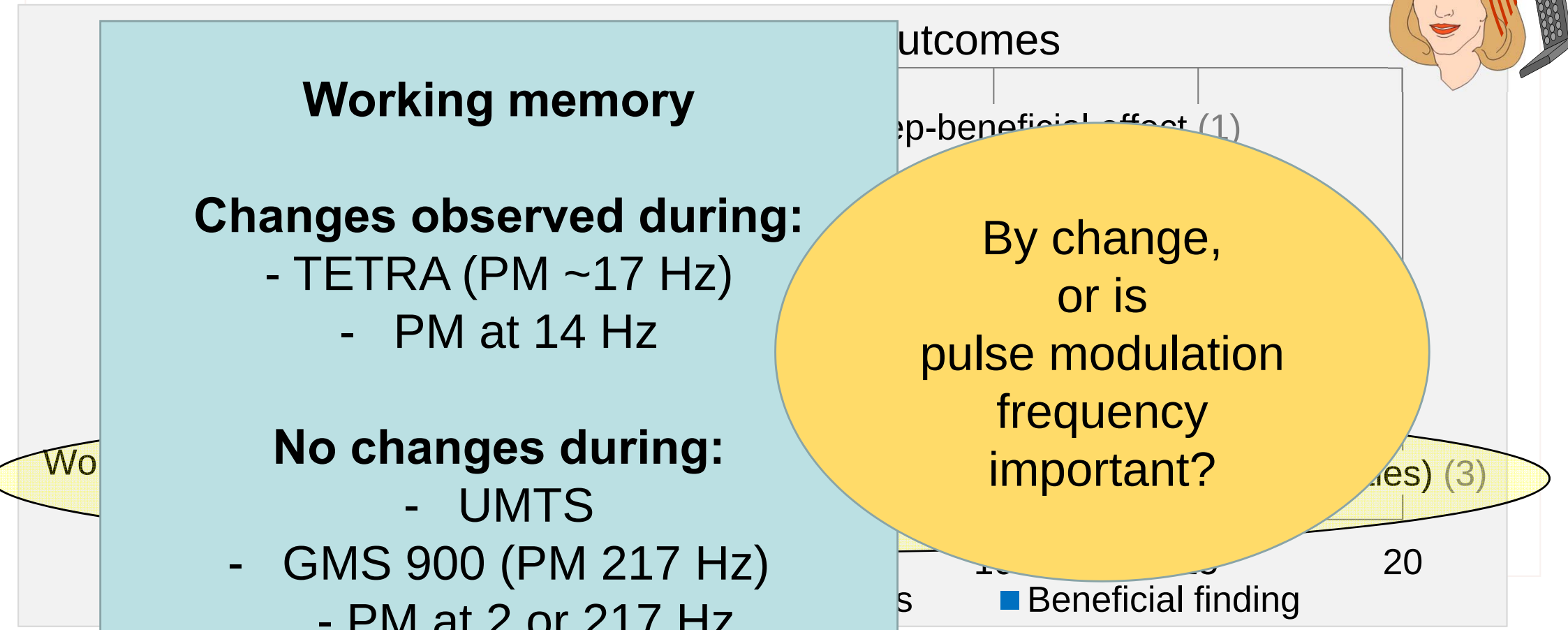


Working memory

Changes observed during:
- TETRA (PM ~17 Hz)
- PM at 14 Hz

No changes during:
- UMTS
- GMS 900 (PM 217 Hz)
- PM at 2 or 217 Hz

By change,
or is
pulse modulation
frequency
important?



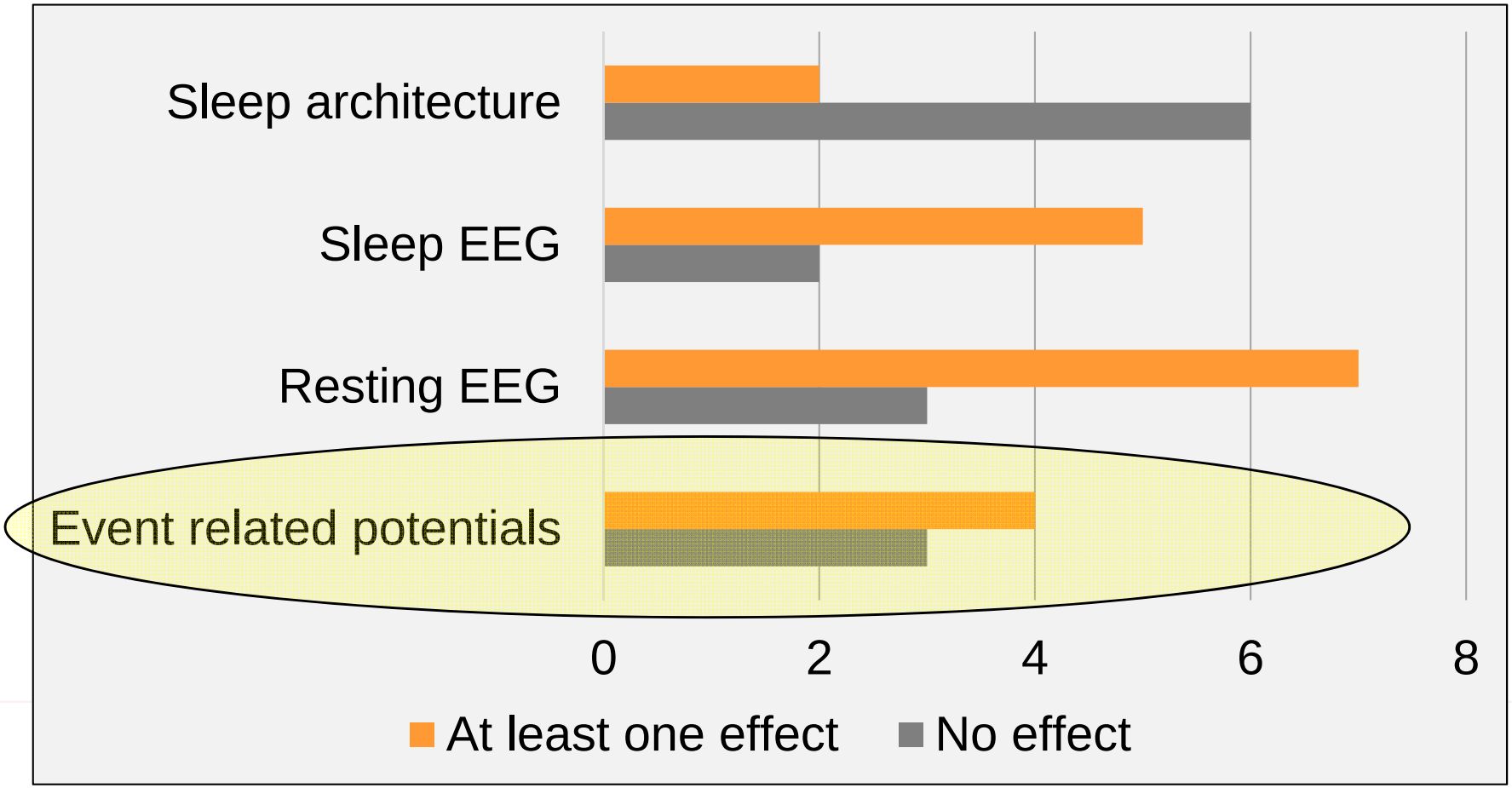
1. Lus
2. Sauter et al. (2015)
3. Leung et al. (2011), Schmid et al. (2012a), Sauter et al. (2015)

Brain electrical activity

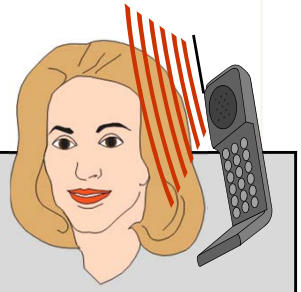
Electroencephalogram (EEG)

- **Produced** by nerve cell activity
- **Normal variations** due to e.g. emotions, cognitive processes, sleepiness, clear differences between sleep awake and sleep and between different sleep stages
- **Pathological changes** by diseases affecting the brain (e.g. epilepsy, Alzheimer's, some psychiatric conditions)

Brain electrical activity



Event related potentials



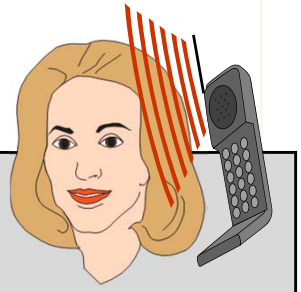
Mobile phone handset related exposures of head

Number of studies	Participants (n)	Type of exposure	Frequency SAR	Finding
2[1]	**Healthy adults** (11–62)	GSM, UMTS	~900, 1900 MHz 0.5–1.7 W/kg	Different events and different effects
3[2]	(25–30)	TETRA, UMTS	385, 1947 MHz 1.75–6 W/kg	No effect
1[3]	**Adolescents** (41)	GMS, UMTS	~900, 1900 MHz 0.7, 1.7 W/kg	Different effects with GSM and UMTS
1[4]	**Epilepsy pat.** (10)	GSM	900 MHz 0.5 W/kg	Effects on motor evoked potentials

1: Leung et al (2011), Vecchio et al. (2012a)
2: Trunk et al. (2013, 2014); Eggert et al. (2015)
3: Leung et al (2011)
4: Tombini et al. (2014)

Event related potentials

Mobile phone handset related exposures of head



Number of studies	Participants (n)	Type of exposure	Frequency SAR	Finding
2[1]	**Healthy adul** (11–62		lz	Different events and different effects
3[2]	(25–			No effect
1[3]	**Adolescents** (41)		lz , 1.7 W/kg	Different effects with GSM and UMTS
1[4]	**Epilepsy pat.** (10)	GSM	900 MHz 0.5 W/kg	Effects on motor evoked potentials

No consistent pattern:
- findings
- exposure type
- exposure frequency
- exposure level

1: Leung et al (2011), Vecchio et al. (2012a)
2: Trunk et al. (2013, 2014); Eggert et al. (2015)
3: Leung et al (2011)
4: Tombini et al. (2014)

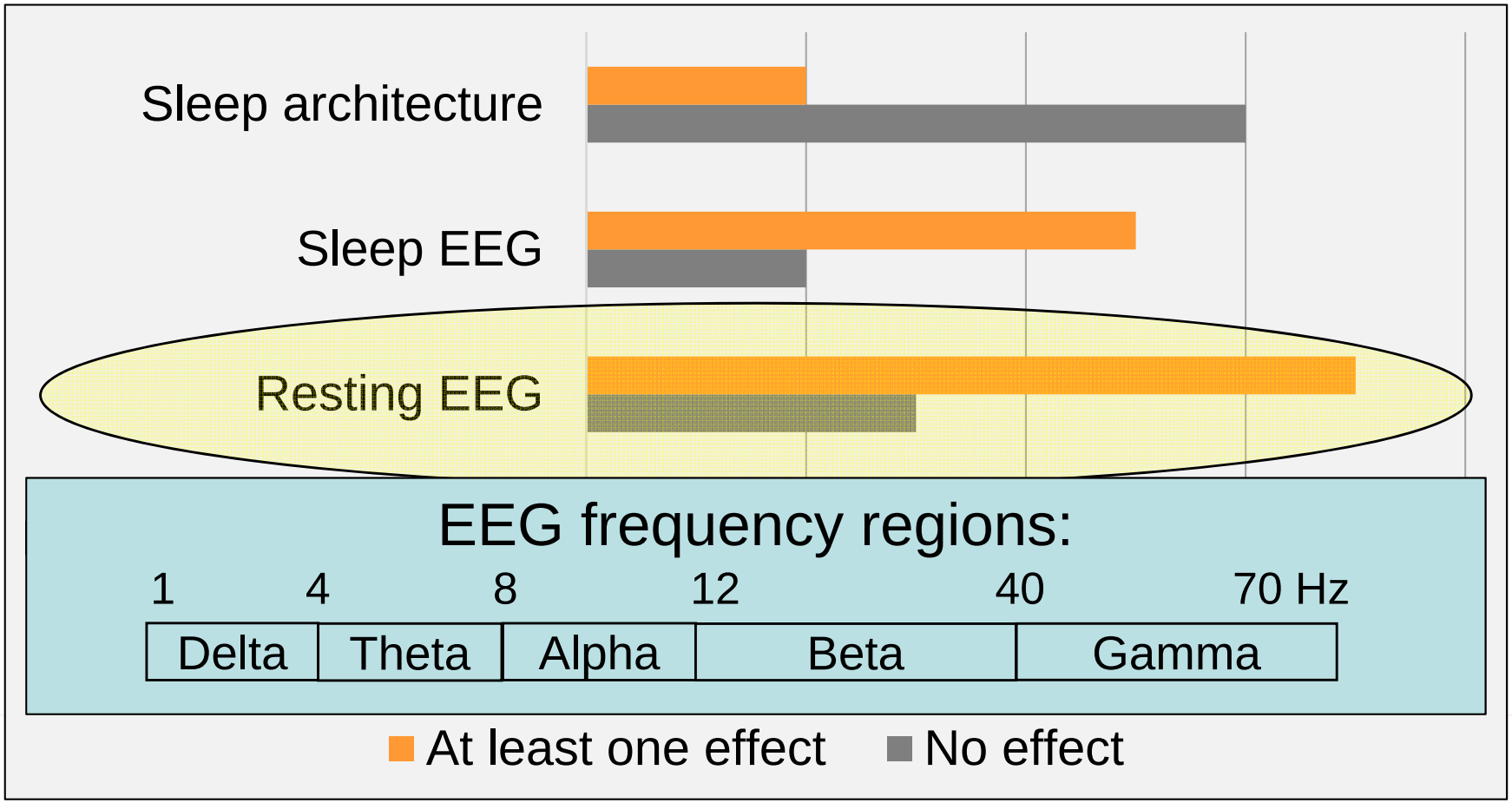
Event related potentials

WiFi related exposure (very low exposure level)

Study	**Participants** (n)	**Frequency** **Electric field**	**Finding**
Papageorgiou et al. (2011)	**Healthy adults** (30)	2450 MHz 0.49 V/m	Opposite **effect** on males and females

Replication needed

Resting/waking EEG



Resting/waking EEG

Healthy adults	n	Exposure type	Frequency (MHz)	SAR (W/kg)	1 4 8 12 40 70 Hz Delta | Theta | Alpha | Beta | Gamma	Eyes
Hinrikus et al. (2011)	14	PM, 7-70 Hz	450	0.3	7 Hz 14 Hz 21 Hz 40 Hz 70 Hz	
Suhhova et al. (2013)	15	PM, 40 Hz	450	0.3	No effect Increased power	
Ghosn et al. (2013)	26	GSM	900	0.49		
Perentos et al. (2013)	72	GSM CW	900 900	0.06 1.95	Reduced power	
Trunk et al. (2013)	17	UMTS	1947	0.49		
Trunk et al. (2015)	21	UMTS	1947	0.49		
Zentai et al. (2015)	25	WiFi	2453	0.0018		
Adolescents						
Loughran et al. (2013)	22	GSM	900	0.35 1.33		

Resting/waking EEG

Healthy adults	n	Exposure type	Frequency (MHz)	SAR (W/kg)	1 4 8 12 40 70 Hz Delta Theta Alpha Beta Gamma	Eyes
Hinrikus						
Suhhova et al. (2013)	15	PM, 40 Hz	450	0.3		
Ghosn et al. (2013)	26	GSM	900	0.49	No effect / Increased power	
Perentos et al. (2013)	72	GSM CW	900 900	0.06 1.95	Reduced power	
Trunk et al. (2013)	17	UMTS	1947	0.49		
Trunk et al. (2015)	21	UMTS	1947	0.49		
Zentai et al. (2015)	25	WiFi	2453	0.0018		
Adolescents						
Loughran et al. (2013)	22	GSM	900	0.35 1.33		

Largest effects with ratios:

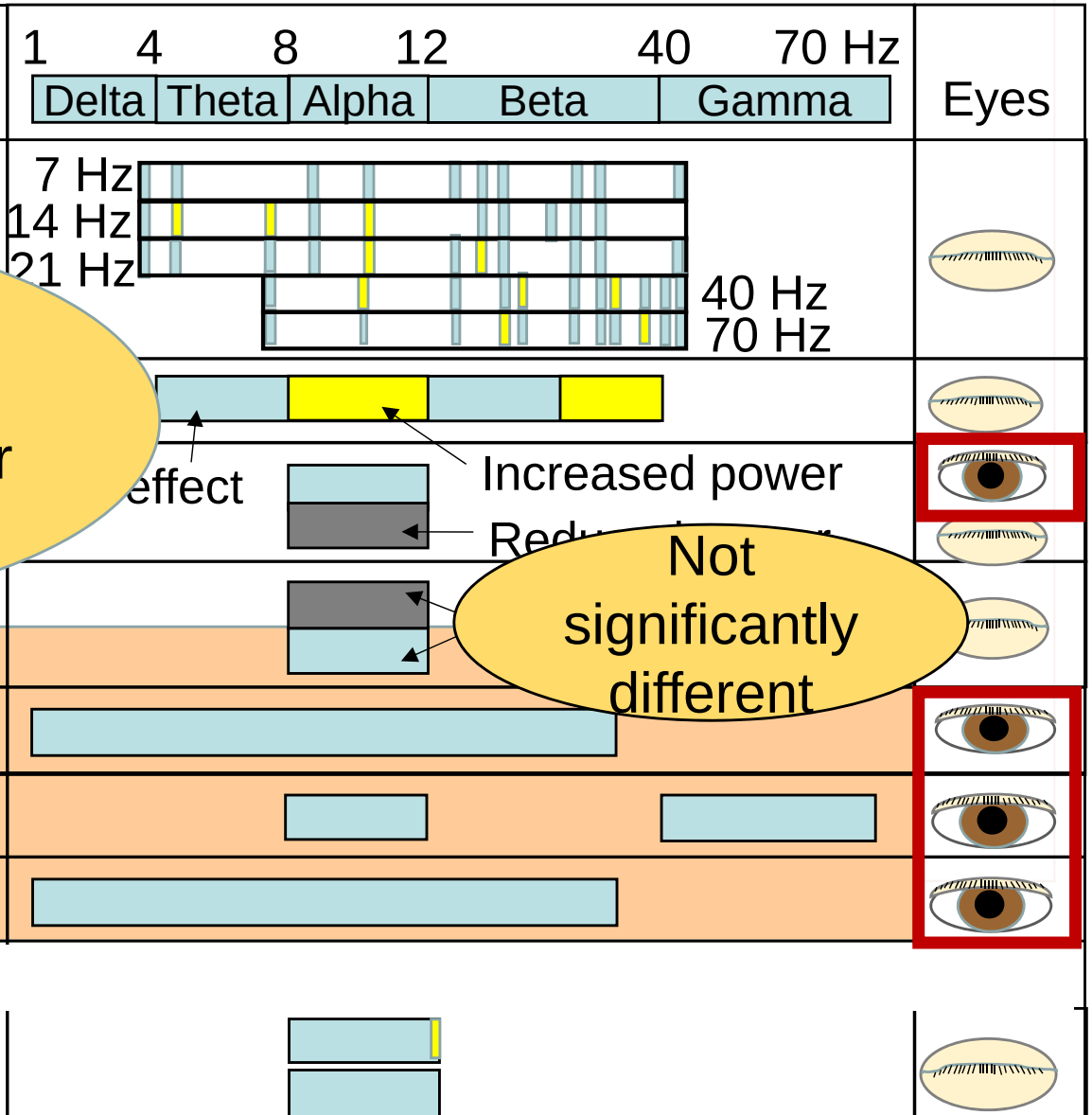
$$\frac{\text{EEG frequency}}{\text{Modulation frequency}} = 0.25, 0.5, 0.75$$

Real pattern or artefacts?

Replication needed

Resting/waking EEG

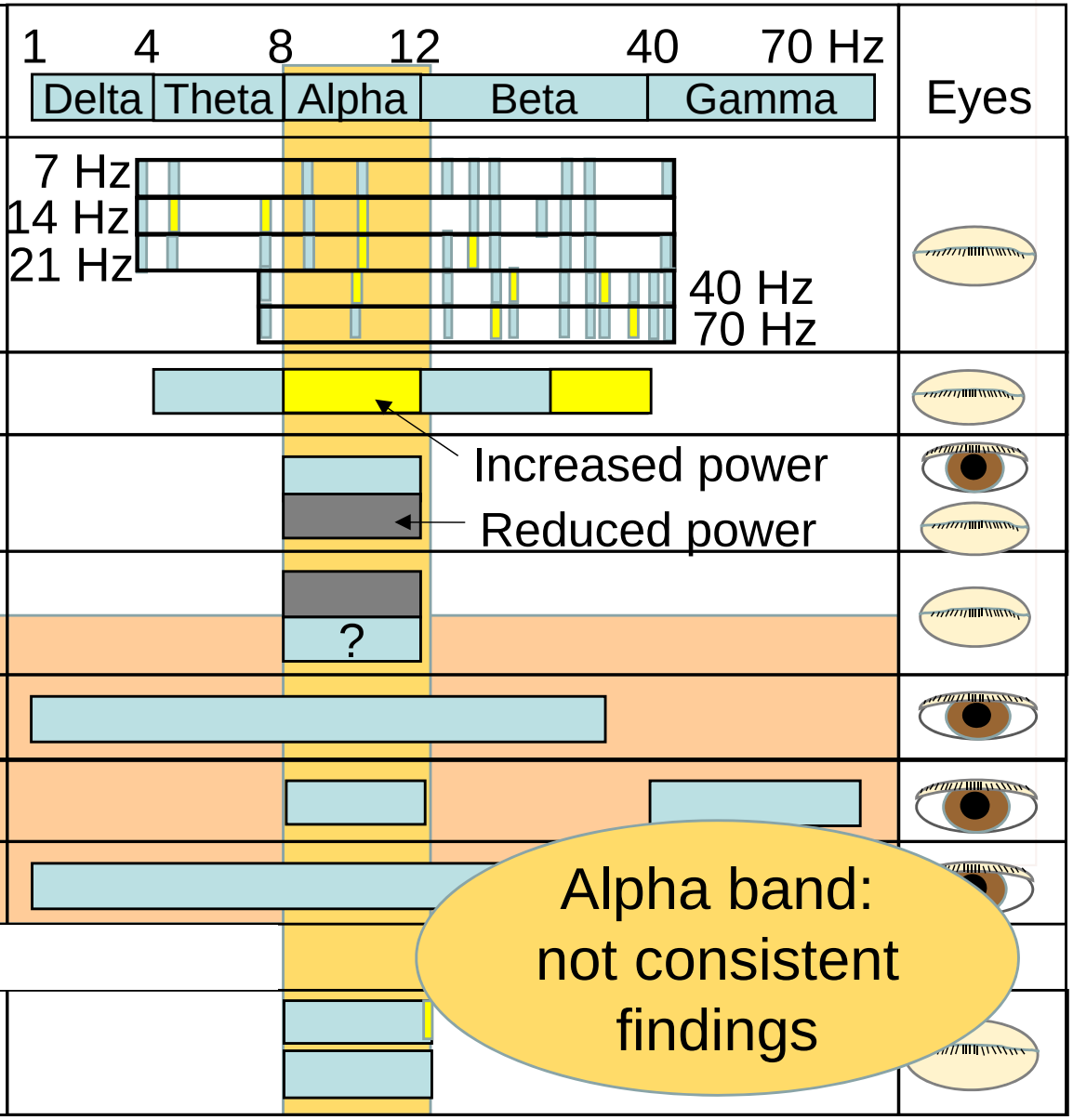
Healthy adults	n	Exposure type	Frequency (MHz)	SAR (W/kg)	Eyes
Hinrikus et al. (2011)	14	PM, 7-70 H	450	0.3	
Suhhova et al. (2013)	15	P			
Ghosn et al. (2013)	26	GS			
Perentos et al. (2013)	72	GSM		0.06	
		CW	900	1.95	
Trunk et al. (2013)	17	UMTS	1947	0.49	
Trunk et al. (2015)	21	UMTS	1947	0.49	
Zentai et al. (2015)	25	WiFi	2453	0.0018	
Adolescents					
Loughran et al. (2013)	22	GSM	900	0.35 1.33	



Effects depending on **pulse modulation** or **eyes closed**?

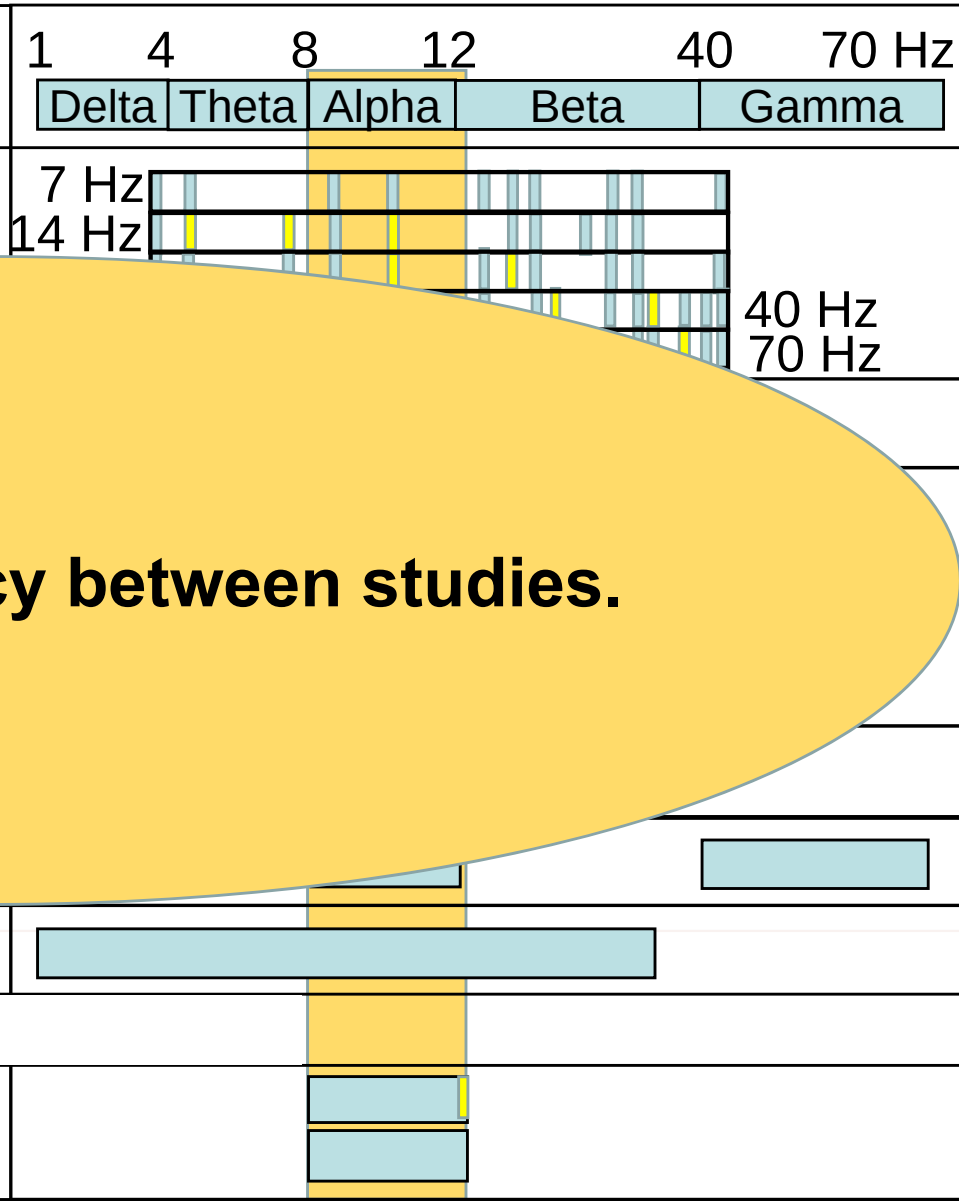
Resting/waking EEG

Healthy adults	n	Exposure type	Frequency (MHz)	SAR (W/kg)	Eyes
Hinrikus et al. (2011)	14	PM, 7-70 Hz	450	0.3	
Suhhova et al. (2013)	15	PM, 40 Hz	450	0.3	
Ghosn et al. (2013)	26	GSM	900	0.49	
Perentos et al. (2013)	72	GSM	900	0.06	
		CW	900	1.95	
Trunk et al. (2013)	17	UMTS	1947	0.49	
Trunk et al. (2015)	21	UMTS	1947	0.49	
Zentai et al. (2015)	25	WiFi	2453	0.0018	
Adolescents					
Loughran et al. (2013)	22	GSM	900	0.35 1.33	



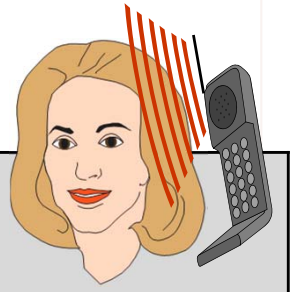
Resting/waking EEG

Healthy adults	n	Exposure type	Frequency (MHz)	SAR (W/kg)	Eyes
Hinrikus et al. (2011)	14	PM, 7-70 Hz	450	0.3	
Suhhova et al. (2013)					
Ghosn (2013					
Perent al. (2013)					
Trunk et al. (2013)	17				
Trunk et al. (2015)	21	UMTS			
Zentai et al. (2015)	25	WiFi	2453	0.0018	
Adolescents					
Loughran et al. (2013)	22	GSM	900	0.35 1.33	



No clear consistency between studies.

Resting/waking EEG

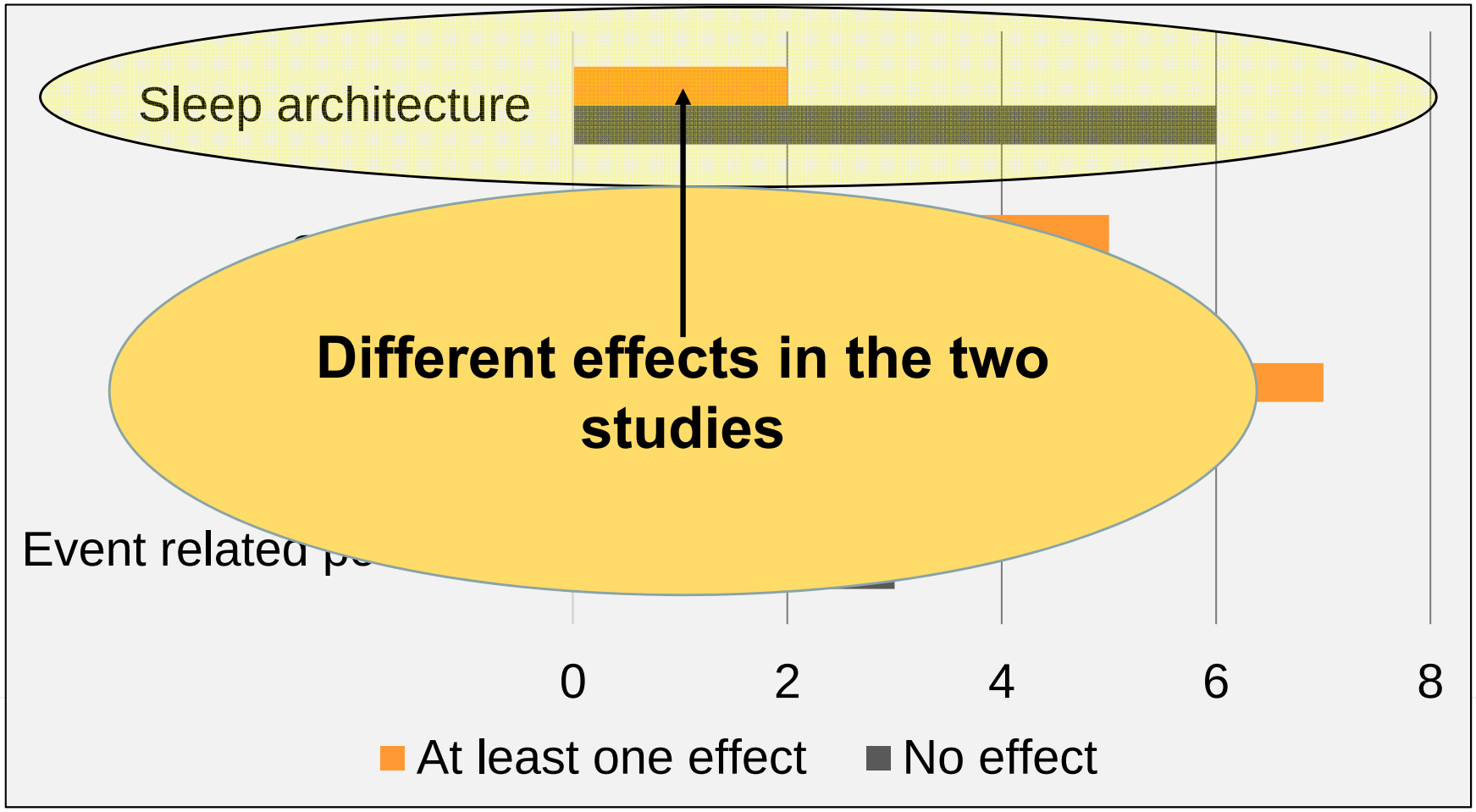


Patients with epilepsy

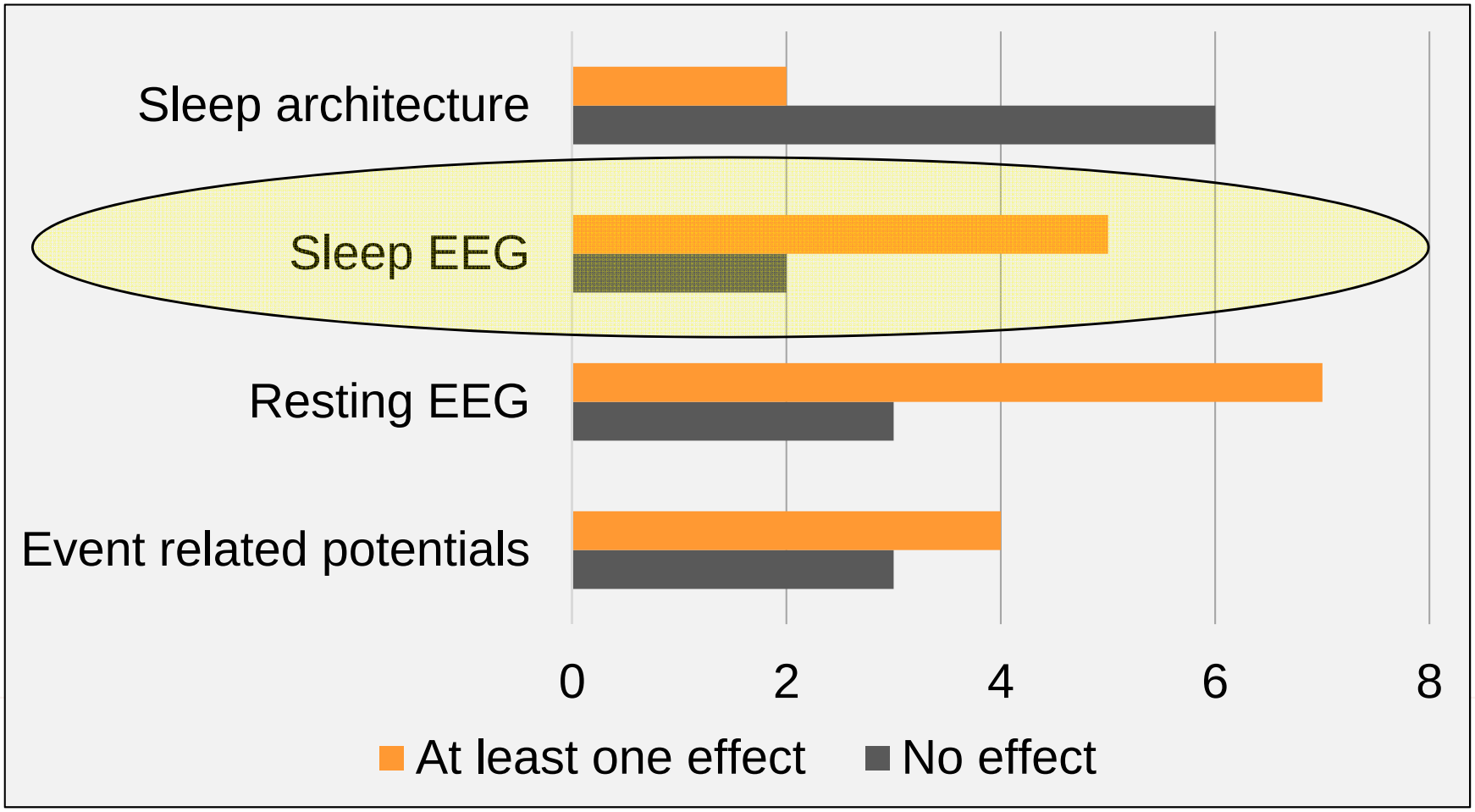
Study	n	Type, frequency SAR	Finding
Vecchio et al. (2012b)	10	GSM, 902.5 MHz 0.5 W/kg	Indication of **increased interhemispheric coherence** (details between studies differ)
Curcio et al. (2015)	12		

Independent replication and further research needed

Sleeping EEG



Sleeping EEG



Sleeping EEG

Healthy adults	n	Type, modulation	Frequency (MHz)	SAR (W/kg)	0.5 5 11 15 30 Hz Spin-del
Loughran et al. (2012)	20	GSM	894.6	0.67	NREM
Schmid et al. (2012a)	30	PM, 14 Hz PM 217 Hz	900	2.0	REM
Schmid et al. (2012b)	23	PM, 2 Hz	900	2.0	NREM REM
Lustenberger et al. (2013)	16	PM, 0.25 & 0.8 Hz	900	1.0	
Lustenberger et al. (2015)	19	PM, 2 Hz	900	2.0	
Nakatani-Enomoto et al. (2013)	19	GSM	894.6	1.5	
Healthy and IEI-EMF adults					
Lowden et al. (2011)	18/ 14	GSM	884	1.4	First ½ h First h Second h

Sleeping EEG

Healthy adults	n	Type, modulation	Frequency (MHz)	SAR (W/kg)	0.5 5 11 15 30 Hz; Spin-del
Loughran et al. (2012)			894.6	0.67	NREM
Schmid et al.				2.0	REM
Schr				0	NREM REM
Lus (20					
Lust (2015)				.0	
Nakatani-E al. (2013)				1.5	
Healthy and IEI-EMF adults					
Lowden et al. (2011)	18/ 14	GSM	884	1.4	First ½ h First h Second h

All exposures before sleep

Only increased EEG power, but:

- affected frequencies and sleep stages varied
- No obvious reason why two studies did not give any effect

Summary

No or few indications of effects without any confirmation:

- Measurable temperature increase with SAR < 2 W/kg
- Perception, symptoms and well-being
- Cardiovascular and autonomic nervous system

Some few indications of effects, but inconsistencies:

- Cerebral metabolism and blood flow
- Cognitive performance

Majority of studies indicating effects, but some inconsistencies:

- Event related potentials
- Resting/waking EEG
- Sleeping EEG (but not sleep architecture)

Summary

Role of type of exposure?

- Some indications of importance of pulse modulation, but this needs to be confirmed

Dose-response effects?

- Over all no indication

Study groups

- No indication that **IEI-EMF** individuals or **adolescents** are more sensitive than healthy adults
- Suggested effects on **epileptic patients** (brain electrical activity) need to be followed up.

Issues

False positive finding?

- Many conditions and parameters tested in some studies and often without correction for multiple tests
- Potential artefacts by EMF interference with recorded signals

False negative findings?

- Large individual differences
- Rarely calculation of statistical power

Difficult to compare studies

- Great variations in protocols

Conclusion

Brain electrical activity studies most interesting to follow up with

- comparable protocols
- high quality

ICNIRP
INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION

ICNIRP 8th INTERNATIONAL NIR WORKSHOP

Cape Town, South Africa, 9-11 May 2016

Volunteer studies 2011-2015

Included

Excluded

	Cognitive function	Brain electrical activity	Brain meta-bolism & blood flow	Symptoms, wellbeing	Auditive, vestibular, ocular systems	Neuro-endocrin system	Cardio-vascular, Autonomic nervous system	Tempe-rature	Cancer related
Bamiou, D. E., Ceranic, B., Vickers, D., Zamyslowska-Szmytke, E., Cox, R., Chadwick, P., & Luxon, L. M. (2015). Mobile telephone use effects on perception of verticality. Bioelectromagnetics, 36(1), 27-34. Additional analysis of: Bamiou, D. E., Ceranic, B., Cox, R., Watt, H., Chadwick, P., & Luxon, L. M. (2008). Mobile telephone use effects an peripheral audiovestibular function: A case-control study. Bioelectromagnetics, 29(2), 108-117.									
Choi, S. B., Kwon, M. K., Chung, J. W., Park, J. S., Chung, K., & Kim, D. W. (2014). Effects of short-term radiation emitted by WCDMA mobile phones on teenagers and adults. BMC Public Health, 14.									
Curcio G, Mazzucchi E, Della Marca G, Vollono C, Rossini PM. (2015). Electromagnetic fields and EEG spiking rate in patients with focal epilepsy. Clin Neurophysiol. 126(4):659-66.									
Curcio, G., Nardo, D., Perrucci, M. G., Pasqualetti, P., Chen, T. L., Del Gratta, C., . . . Rossini, P. M. (2012). Effects of mobile phone signals over BOLD response while performing a cognitive task. Clin Neurophysiol, 123(1), 129-136.									
Danker-Hopfe, H., Dorn, H., Bahr, A., Anderer, P., & Sauter, C. (2011). Effects of electromagnetic fields emitted by mobile phones (GSM 900 and WCDMA/UMTS) on the macrostructure of sleep. Journal of Sleep Research, 20(1), 73-81. Danker-Hopfe, H., Dorn, H., Bolz, T., Peter, A., Hansen, M. L., Eggert, T., & Sauter, C. (2016). Effects of mobile phone exposure (GSM 900 and WCDMA/UMTS) on polysomnography based sleep quality: An intra- and inter-individual perspective. Environ Res, 145, 50-60. doi: 10.1016/j.envres.2015.11.011									
Dorn, H., Schmid, G., Eggert, T., Sauter, C., Bolz, T., & Danker-Hopfe, H. (2014). Experimental Investigation of Possible Warmth Perception from a Head Exposure System for Human Provocation Studies with TETRA Handset-like Signals. Bioelectromagnetics, 35(6), 452-458.									

ICNIRP
INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION

ICNIRP 8th INTERNATIONAL NIR WORKSHOP

Cape Town, South Africa, 9-11 May 2016

Volunteer studies 2011-2015

Included

Excluded

	Cognitive function	Brain electrical activity	Brain meta-bolism & blood flow	Symptoms, wellbeing, detection	Auditive, vestibular, ocular systems	Neuro-endocrin system	Cardio-vascular, Autonomic nervous system	Tempe-rature	Cancer related
Eggert T, Dorn H, Sauter C, Marasanov A, Hansen M-L, Peter A, Schmid G, Bolz T, Danker-Hopfe H. (2015). Terrestrial Trunked Radio (TETRA) exposure and its impact on slow cortical potentials. Environmental Research 143:112–122. Sauter C, Eggert T, Dorn H, Schmid G, Bolz T, Marasanov A, Hansen ML, Peter A, Danker-Hopfe H. Do signals of a hand-held TETRA transmitter affect cognitive performance, well-being, mood or somatic complaints in healthy young men? Results of a randomized double-blind cross-over provocation study. Environ Res 2015; 140 : 85 – 94									
Eltiti S, Wallace D, Russo R, Fox E. (2015). Aggregated data from two double-blind base station provocation studies comparing individuals with idiopathic environmental intolerance with attribution to electromagnetic fields and controls. Bioelectromagnetics. 36:96-107. Pooled analysis of: Eltiti, S., Wallace, D., Ridgewell, A., Zougkou, K., Russo, R., Sepulveda, F., . . . Fox, E. (2007). Does short-term exposure to mobile phone base station signals increase symptoms in individuals who report sensitivity to electromagnetic fields? A double-blind randomized provocation study. Environ Health Perspect, 115(11), 1603-1608. and Wallace, D., Eltiti, S., Ridgewel, A., Garner, K., Russo, R., Sepulveda, F., . . . Fox, E. (2010). Do TETRA (Airwave) Base Station Signals Have a Short-Term Impact on Health and Well-Being? A Randomized Double-Blind Provocation Study. Environmental Health Perspectives, 118(6), 735-741.									
Ghosn R., Yahia-Cherif L., Hugueville L., Ducorps A., Lemaréchal J-D., Thuróczy G., de Seze R., Brahim Selmaoui B. (2015). Radiofrequency signal affects alpha band in resting electroencephalogram. J Neurophysiol 113:2753-2759.									
Ghosn, R., Thuroczy, G., Loos, N., Brenet-Dufour, V., Liabeuf, S., de Seze, R., & Selmaoui, B. (2012). Effects of GSM 900 MHz on middle cerebral artery blood flow assessed by transcranial Doppler sonography. Radiat Res, 178(6), 543-550. doi: 10.1667/RR3007.1									
Hinrikus, H., Bachmann, M., & Lass, J. (2011). Parametric mechanism of excitation of the electroencephalographic rhythms by modulated microwave radiation. *Int J Radiat Biol, 87*(11), 1077-1085.									

ICNIRP
INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION

ICNIRP 8th INTERNATIONAL NIR WORKSHOP

Cape Town, South Africa, 9-11 May 2016

Volunteer studies 2011-2015

Included

Excluded

	Cognitive function	Brain electrical activity	Brain meta-bolism & blood flow	Symptoms, wellbeing	Auditive, vestibular, ocular systems	Neuro-endocrin system	Cardio-vascular, Autonomic nervous system	Tempe-rature	Cancer related
Kwon, M. K., Choi, J. Y., Kim, S. K., Yoo, T. K., & Kim, D. W. (2012a). Effects of radiation emitted by WCDMA mobile phones on electromagnetic hypersensitive subjects. *Environmental Health, 11*.									
Kwon, M. S., Vorobyev, V., Kannala, S., Laine, M., Rinne, J. O., Toivonen, T., . . . Hamalainen, H. (2011). GSM mobile phone radiation suppresses brain glucose metabolism. *Journal of Cerebral Blood Flow and Metabolism, 31*(12), 2293-2301.									
Kwon, M. S., Vorobyev, V., Kannala, S., Laine, M., Rinne, J. O., Toivonen, T., . . . Hamalainen, H. (2012b). No effects of short-term GSM mobile phone radiation on cerebral blood flow measured using positron emission tomography. *Bioelectromagnetics, 33*(3), 247-256.									
Leung, S., Croft, R. J., McKenzie, R. J., Iskra, S., Silber, B., Cooper, N. R., . . . Simpson, D. (2011). Effects of 2G and 3G mobile phones on performance and electrophysiology in adolescents, young adults and older adults. *Clin Neurophysiol, 122*(11), 2203-2216.									
Lindholm, H., Alanko, T., Rintamaki, H., Kannala, S., Toivonen, T., Sistonen, H., . . . Hietanen, M. (2011). Thermal effects of mobile phone RF fields on children: a provocation study. Prog Biophys Mol Biol, 107(3), 399-403.									
Loos, N., Thuroczy, G., Ghosn, R., Brenet-Dufour, V., Liabeuf, S., Selmaoui, B., . . . de Seze, R. (2013). Is the Effect of Mobile Phone Radiofrequency Waves on Human Skin Perfusion Non-Thermal? *Microcirculation, 20*(7), 629-636.									
Loughran, S. P., Benz, D. C., Schmid, M. R., Murbach, M., Kuster, N., & Achermann, P. (2013). No increased sensitivity in brain activity of adolescents exposed to mobile phone-like emissions. Clinical Neurophysiology, 124(7), 1303-1308.									
Loughran, S. P., McKenzie, R. J., Jackson, M. L., Howard, M. E., & Croft, R. J. (2012). Individual differences in the effects of mobile phone exposure on human sleep: Rethinking the problem. *Bioelectromagnetics, 33*(1), 86-93.									
Lowden, A., Akerstedt, T., Ingre, M., Wiholm, C., Hillert, L., Kuster, N., . . . Arnetz, B. (2011). Sleep After Mobile Phone Exposure in Subjects With Mobile Phone-Related Symptoms. *Bioelectromagnetics, 32*(1), 4-14.									

ICNIRP
INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION

ICNIRP 8th INTERNATIONAL NIR WORKSHOP

Cape Town, South Africa, 9-11 May 2016

Volunteer studies 2011-2015

Included

Excluded

	Cognitive function	Brain electrical activity	Brain meta-bolism & blood flow	Symptoms, wellbeing	Auditive, vestibular, ocular systems	Neuro-endocrin system	Cardio-vascular, Autonomic nervous system	Tempe-rature	Cancer related
Lustenberger C., Murbach M., Tüshaus L., Wehrle F., Achermann P., Huber R. (2015) Inter-individual and intra-individual variation of the effects of pulsed RF EMF exposure on the human sleep EEG. Bioelectromagnetics, 36, 3, 169-177.									
Lustenberger, C., Murbach, M., Dürr, R., Schmid, M. R., Kuster, N., Achermann, P., & Huber, R. (2013). Stimulation of the brain with radiofrequency electromagnetic field pulses affects sleep-dependent performance improvement. Brain Stimulation, 6(5), 805–811.									
Nakatani-Enomoto, S., Furubayashi, T., Ushiyama, A., Groiss, S. J., Ueshima, K., Sokejima, S., … Ugawa, Y. (2013). Effects of Electromagnetic Fields Emitted From W-CDMA-like Mobile Phones on Sleep in Humans, Bioelectromagnetics, 34:589-598									
Nieto-Hernandez, R., Williams, J., Cleare, A. J., Landau, S., Wessely, S., & Rubin, G. J. (2011). Can exposure to a terrestrial trunked radio (TETRA)-like signal cause symptoms? A randomised double-blind provocation study. *Occupational and Environmental Medicine, 68*(5), 339-344.									
Papageorgiou, C. C., Hountala, C. D., Maganioti, A. E., Kyprianou, M. A., Rabavilas, A. D., Papadimitriou, G. N., & Capsalis, C. N. (2011). Effects of wi-fi signals on the p300 component of event-related potentials during an auditory haying task. Journal of Integrative Neuroscience, 10(2), 189–202									
Parazzini, M., Ravazzani, P., Thuroczy, G., Molnar, F. B., Ardesi, G., Sacchettini, A., & Mainardi, L. T. (2013). Nonlinear heart rate variability measures under electromagnetic fields produced by GSM cellular phones. *Electromagn Biol Med, 32*(2), 173-181. Additional analysis of: Parazzini, M., Ravazzani, P., Tognola, G., Thuroczy, G., Molnar, F. B., Sacchettini, A., . . . Mainardi, L. T. (2007). Electromagnetic fields produced by GSM cellular phones and heart rate variability. Bioelectromagnetics, 28(2), 122-129									
Perentos, N., Croft, R. J., McKenzie, R. J., & Cosic, I. (2013). The alpha band of the resting electroencephalogram under pulsed and continuous radio frequency exposures. IEEE Transactions on Bio-Medical Engineering, 60(6):1702–1710.									
Sauter, C., Dorn, H., Bahr, A., Hansen, M. L., Peter, A., Bajbouj, M., & Danker-Hopfe, H. (2011). Effects of exposure to electromagnetic fields emitted by GSM 900 and WCDMA mobile phones on cognitive function in young male subjects. *Bioelectromagnetics, 32*(3), 179-190.									

ICNIRP
INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION

ICNIRP 8th INTERNATIONAL NIR WORKSHOP

Cape Town, South Africa, 9-11 May 2016

Volunteer studies 2011-2015

Included

Excluded

	Cognitive function	Brain electrical activity	Brain meta-bolism & blood flow	Symptoms, wellbeing	Auditive, vestibular, ocular systems	Neuro-endocrin system	Cardio-vascular, Autonomic nervous system	Tempe-rature	Cancer related
Schmid, M. R., Loughran, S. P., Regel, S. J., Murbach, M., Bratic Grunauer, A., Rusterholz, T., . . . Achermann, P. (2012a). Sleep EEG alterations: effects of different pulse-modulated radio frequency electromagnetic fields. *J Sleep Res, 21*(1), 50-58.									
Schmid, M. R., Murbach, M., Lustenberger, C., Maire, M., Kuster, N., Achermann, P., & Loughran, S. P. (2012b). Sleep EEG alterations: effects of pulsed magnetic fields versus pulse-modulated radio frequency electromagnetic fields. *J Sleep Res, 21*(6), 620-629.									
Spichtig, S., Scholkmann, F., Chin, L., Lehmann, H., & Wolf, M. (2012). Assessment of intermittent UMTS electromagnetic field effects on blood circulation in the human auditory region using a near-infrared system. *Bioelectromagnetics, 33*(1), 40-54.									
Suhhova, A., Bachmann, M., Karai, D., Lass, J., & Hinrikus, H. (2013). Effect of microwave radiation on human EEG at two different levels of exposure. Bioelectromagnetics, 34(4), 264–274									
Tombini, M., Pellegrino, G., Pasqualetti, P., Assenza, G., Benvenga, A., Fabrizio, E., & Rossini, P. M. (2013). Mobile Phone Emissions Modulate Brain Excitability in Patients with Focal Epilepsy. Brain Stimulation, 6(3), 448-454.									
Trunk A, Stefanics G, Zentai N, Bacskay I, Felinger A, Thuróczy G, Hernádi I. (2014). Lack of interaction between concurrent caffeine and mobile phone exposure on visual target detection: An ERP study. Pharmacology, Biochemistry and Behavior 124:412–420. Trunk A, Stefanics G, Zentai N, Bacskay I, Felinger A, Thuróczy G, Hernádi I. (2015) Effects of concurrent caffeine and mobile phone exposure on local target probability processing in the human brain. Scientific Reports. 23;5:14434.									
Trunk A, Stefanics G, Zentai N, Kovacs-Balint Z, Thuroczy G, Hernadi I (2013). No effects of a single 3G UMTS mobile phone exposure on spontaneous EEG activity, ERP correlates, and automatic deviance detection. Bioelectromagnetics. 34:31-42									
Vecchio, F., Buffo, P., Sergio, S., Iacoviello, D., Rossini, P. M., & Babiloni, C. (2012a). Mobile phone emission modulates event-related desynchronization of alpha rhythms and cognitive-motor performance in healthy humans. *Clinical Neurophysiology, 123*(1), 121-128.									
Vecchio, F., Tombini, M., Buffo, P., Assenza, G., Pellegrino, G., Benvenga, A., . . . Rossini, P. M. (2012b). Mobile phone emission increases inter-hemispheric functional coupling of electroencephalographic alpha rhythms in epileptic patients. *International Journal of Psychophysiology, 84*(2), 164-171.									

ICNIRP
INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION

ICNIRP 8th INTERNATIONAL NIR WORKSHOP

Cape Town, South Africa, 9-11 May 2016

Volunteer studies 2011-2015

Included

Excluded

	Cognitive function	Brain electrical activity	Brain meta-bolism & blood flow	Symptoms, wellbeing	Auditive, vestibular, ocular systems	Neuro-endocrin system	Cardio-vascular, Autonomic nervous system	Tempe-rature	Cancer related
Vecsei Z, Csatho A, Thuroczy G, Hernadi I. (2013). Effect of a single 30 min UMTS mobile phone-like exposure on the thermal pain threshold of young healthy volunteers. Bioelectromagnetics. 34:530-541.									
Wallace, D., Eltiti, S., Ridgewell, A., Garner, K., Russo, R., Sepulveda, F., . . . Fox, E. (2012). Cognitive and physiological responses in humans exposed to a TETRA base station signal in relation to perceived electromagnetic hypersensitivity. *Bioelectromagnetics, 33*(1), 23-39.									
Zentai N, Csatho A, Trunk A, et al. (2015). No Effects of Acute Exposure to Wi-Fi Electromagnetic Fields on Spontaneous EEG Activity and Psychomotor Vigilance in Healthy Human Volunteers. Radiation Research. 184:568-577									
Alhusseiny A, Al-Nimer M, Majeed A (2012). Electromagnetic energy radiated from mobile phone alters electrocardiographic records of patients with ischemic heart disease. Ann Med Health Sci Res, 2(2):146-151									
Alsanosi, A. A., Al-Momani, M. O., Hagr, A. A., Almomani, F. M., Shami, I. M., & Al-Habeeb, S. F. (2013). The acute auditory effects of exposure for 60 minutes to mobile's electromagnetic field. *Saudi Med J, 34*(2), 142-146.									
Balachandran R et al. (2012). Effects of Bluetooth device electromagnetic field on hearing: pilot study. J Laryngol Otol, 126(4):345-348.									
Barutcu I et al. (2011). Do mobile phones pose a potential risk to autonomic modulation of the heart? Pacing Clin Electrophysiol, 34(11):1511-1514.									
Bortkiewicz, A., Gadzicka, E., Szymczak, W., & Zmyslony, M. (2012). Changes in tympanic temperature during the exposure to electromagnetic fields emitted by mobile phone. Int J Occup Med Environ Health, 25(2):145-150.									
Cam, S. T., & Seyhan, N. (2012). Single-strand DNA breaks in human hair root cells exposed to mobile phone radiation. *Int J Radiat Biol, 88*(5), 420-424.									
Colletti, V., Mandala, M., Manganotti, P., Ramat, S., Sacchetto, L., & Colletti, L. (2011). Intraoperative observation of changes in cochlear nerve action potentials during exposure to electromagnetic fields generated by mobile phones. Journal of Neurology Neurosurgery and Psychiatry, 82(7), 766-771.									
Devasia T, Nandra A, Kareem H, Manu MK, Thakkar AS. (2014). Acute Effect of Mobile Phone on Cardiac Electrical Activity in Healthy Volunteers. International Journal of Clinical Medicine, 5 (5): 167 - 170									

ICNIRP
INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION

ICNIRP 8th INTERNATIONAL NIR WORKSHOP

Cape Town, South Africa, 9-11 May 2016

Volunteer studies 2011-2015

Included
Excluded

	Cognitive function	Brain electrical activity	Brain meta-bolism & blood flow	Symptoms, wellbeing	Auditive, vestibular, ocular systems	Neuro-endocrin system	Cardio-vascular, Autonomic nervous system	Tempe-rature	Cancer related
Faust O et al. (2011). Effects of mobile phone radiation on cardiac health. J Mechanics Med Biol, 11(5):1241-1253.									
Geronikolou, S. A., Chamakou, A., Mantzou, A., Chrousos, G., & Kanaka-Gantenbein, C. (2015). Frequent cellular phone use modifies hypothalamic-pituitary-adrenal axis response to a cellular phone call after mental stress in healthy children and adolescents: A pilot study. Science of the Total Environment, 536, 182-188.									
Hareuveny, R., Eliyahu, I., Luria, R., Meiran, N., & Margaliot, M. (2011). Cognitive effects of cellular phones: a possible role of non-radiofrequency radiation factors. Bioelectromagnetics, 32(7), 585–588.									
Havas, M., & Marrongelle, J. (2013). Replication of heart rate variability provocation study with 2.4-GHz cordless phone confirms original findings. *Electromagn Biol Med, 32*(2), 253-266.									
Huttunen, P., Savinainen, A., Hänninen, O., & Myllylä, R. (2011). Involuntary human hand movements due to FM radio waves in a moving van. Acta Physiologica Hungarica 98(2):157–164.									
Lahiri, B.B., Bagavathiappan, S., Soumya, C; Jayakumar, T; Philip, J. (2015). Infrared thermography based studies on mobile phone induced heating. Infrared Physics & Technology. 71:242-251.									
Lv, B., Chen, Z., Wu, T., Shao, Q., Yan, D., Ma, L., . . . Xie, Y. (2014). The alteration of spontaneous low frequency oscillations caused by acute electromagnetic fields exposure. Clinical Neurophysiology, 125(2), 277-286.									
Malek, F., Rani, K. A., Rahim, H. A., & Omar, M. H. (2015). Effect of Short-Term Mobile Phone Base Station Exposure on Cognitive Performance, Body Temperature, Heart Rate and Blood Pressure of Malaysians. *Scientific Reports, 5*.									
Mandala, M., Colletti, V., Sacchetto, L., Manganotti, P., Ramat, S., Marcocci, A., & Colletti, L. (2014). Effect of Bluetooth Headset and Mobile Phone Electromagnetic Fields on the Human Auditory Nerve. *Laryngoscope, 124*(1), 255-259.									
Mollerlokken, O. J., Moen, B. E., Baste, V., Mageroy, N., Oftedal, G., Neto, E., Ersland L, Bjørge L, Torjesen P.A., & Mild, K. H. (2012). No effects of MRI scan on male reproduction hormones. Reproductive Toxicology, 34(1), 133-139									
Mortazavi SMJ, Khademi F, Mortazavi SA. (2014). Introducing a Novel Multi-Phase Method for Effective Screening of the Individuals Diagnosed with Electromagnetic Hypersensitivity. Iranian Journal of Public Health. 43:1724-1725.									

ICNIRP
INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION

ICNIRP 8th INTERNATIONAL NIR WORKSHOP

Cape Town, South Africa, 9-11 May 2016

Volunteer studies 2011-2015

Included

Excluded

	Cognitive function	Brain electrical activity	Brain meta-bolism & blood flow	Symptoms, wellbeing	Auditive, vestibular, ocular systems	Neuro-endocrin system	Cardio-vascular, Autonomic nervous system	Tempe-rature	Cancer related
Mortazavi, S. M. J., Rouintan, M. S., Taeb, S., Dehghan, N., Ghaffarpanah, A. A., Sadeghi, Z., & Ghafouri, F. (2012). Human short-term exposure to electromagnetic fields emitted by mobile phones decreases computer-assisted visual reaction time. *Acta Neurologica Belgica, 112*(2), 171-175.									
Mortazavi, S. M., Mahbudi, A., Atefi, M., Bagheri, S., Bahaedini, N., & Besharati, A. (2011). An old issue and a new look: electromagnetic hypersensitivity caused by radiations emitted by GSM mobile phones. *Technol Health Care, 19*(6)									
Moustafa YM et al. (2001) Effects of acute exposure to the radiofrequency fields of cellular phones on plasma lipid peroxide and antioxidase activities in human erythrocytes. J Pharm Biomed Anal, 26(4), 605-608									
Movvahedi MM, Tavakkoli-Golpayegani A, Mortazavi SA, Haghani M, Razi Z, Shojaie-Fard MB, Zare M, Mina E, Mansourabadi L, Nazari-Jahromi, Safari A, Shokrpour N, Mortazavi SM. (2014). Does exposure to GSM 900 MHz mobile phone radiation affect short-term memory of elementary school students? J Pediatr Neurosci 9 (2): 121 – 124									
Roggeveen S, van Os J, Viechtbauer W, Lousberg R. (2015b) EEG Changes Due to Experimentally Induced 3G Mobile Phone Radiation. PLoS One;10(6):e0129496-1 Roggeveen, S., van Os, J., & Lousberg, R. (2015a). Does the Brain Detect 3G Mobile Phone Radiation Peaks? An Explorative In-Depth Analysis of an Experimental Study. Plos One, 10(5), e0125390.									
Volkow, N. D., Tomasi, D., Wang, G. J., Vaska, P., Fowler, J. S., Telang, F., . . . Wong, C. (2011). Effects of cell phone radiofrequency signal exposure on brain glucose metabolism. JAMA, 305(8), 808-813.									