

Wirkungen der elektromagnetischen Felder des Mobilfunks auf den Gehirnstoffwechsel



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Peter Hensinger MA

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humane Bildung**

Postbankstudie: 70 Stunden / Woche



Bild: Seventyfour_AdobeStock_605624128



Wirkungen der elektromagnetischen Felder des Mobilfunks auf den Gehirnstoffwechsel

1. **Ergebnisse epidemiologischer Studien**
2. **Gehirnfunktionen werden durch elektro-chemische Kopplungen gesteuert und darüber hinaus auf höchster Funktionsebene durch elektromagnetische Frequenzen synchronisiert**
3. **Einfluss elektromagnetischer Felder auf die Neurogenese im Hippocampus**
4. **Schaltzentrale Hippocampus unter Strahlenstress**
5. **Die Hemmung des Gehirndüngers BDNF**
6. **Von den Symptomen zu Wirkmechanismen**
7. **Wirkmechanismus oxidativer Zellstress – Grundlage entzündlicher Erkrankungen**
8. **Der Erkenntnisprozess ist nicht abgeschlossen**
9. **Alternativen durchsetzen!**



Cell phone use and behavioural problems in young children

Hozefa A Divan,¹ Leeka Kheifets,² Carsten Obel,³ Jørn Olsen^{2,3}

► Additional tables are published online only. To view these files please visit the journal online (<http://jech.bmj.com>).

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ABSTRACT

Background Potential health effects of cell phone use in children have not been adequately examined. As children are using cell phones at earlier ages, research among this group has been identified as the highest priority by both national and international organisations. The authors previously reported results from the Danish National Birth Cohort (DNBC), which looked at prenatal and postnatal exposure to cell phone use and behavioural problems at age 7 years. Exposure to cell phones prenatally, and to a lesser degree postnatally, was associated with more behavioural difficulties. The original analysis included nearly 13 000 children who reached age 7 years by November 2006.

Methods To see if a larger, separate group of DNBC children would produce similar results after considering

then the potential rise in health burden could be significant.

Exposure to cell phones is increasingly becoming prevalent among children at younger ages. Also of concern is use by expectant mothers. Previously, we reported an association from the Danish National Birth Cohort (DNBC) for prenatal and postnatal exposure to cell phone use and behavioural problems at age 7 years among nearly 13 000 Danish children born between 1997 and 1999.²

In order to determine whether our original results were a chance finding, or because the initial sample were 'early adopters of technology' who are more likely to have behavioural problems and whose children are likely to have similar behavioural patterns, we analysed a new and separate

Foerster et al. (2018): Gedächtnisleistung, figurales Gedächtnis

Research

A Section 508-conformant HTML version of this article
is available at <https://doi.org/10.1289/EHP2427>.

A Prospective Cohort Study of Adolescents' Memory Performance and Individual Brain Dose of Microwave Radiation from Wireless Communication

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BACKGROUND: The potential impact of microwave radiofrequency electromagnetic fields (RF-EMF) emitted by wireless communication devices on neurocognitive functions of adolescents is controversial. In a previous analysis, we found changes in figural memory scores associated with a higher cumulative RF-EMF brain dose in adolescents.

OBJECTIVE: We aimed to follow-up our previous results using a new study population, dose estimation, and approach to controlling for confounding from media usage itself.

METHODS: RF-EMF brain dose for each participant was modeled. Multivariable linear regression models were fitted on verbal and figural memory score changes over 1 y and on estimated cumulative brain dose and RF-EMF related and unrelated media usage ($n = 669-676$). Because of the hemispheric lateralization of memory, we conducted a laterality analysis for phone call ear preference. To control for the confounding of media use behaviors, a stratified analysis for different media usage groups was also conducted.

RESULTS: We found decreased figural memory scores in association with an interquartile range (IQR) increase in estimated cumulative RF-EMF brain dose scores: -0.22 (95% CI: $-0.47, 0.03$; IQR: 953 mJ/kg per day) in the whole sample, -0.39 (95% CI: $-0.67, -0.10$; IQR: 953 mJ/kg per day) in right-side users ($n = 522$), and -0.26 (95% CI: $-0.42, -0.10$; IQR: 241 mJ/kg per day) when restricted to study participants who used mobile phones. RF-EMF



Foto: Joachim Kirchner, pixelio.de

„Eine prospektive Kohortenstudie zur Gedächtnisleistung von Jugendlichen und die individuelle Hirndosis der Mikrowellenfelder durch Funkkommunikation“

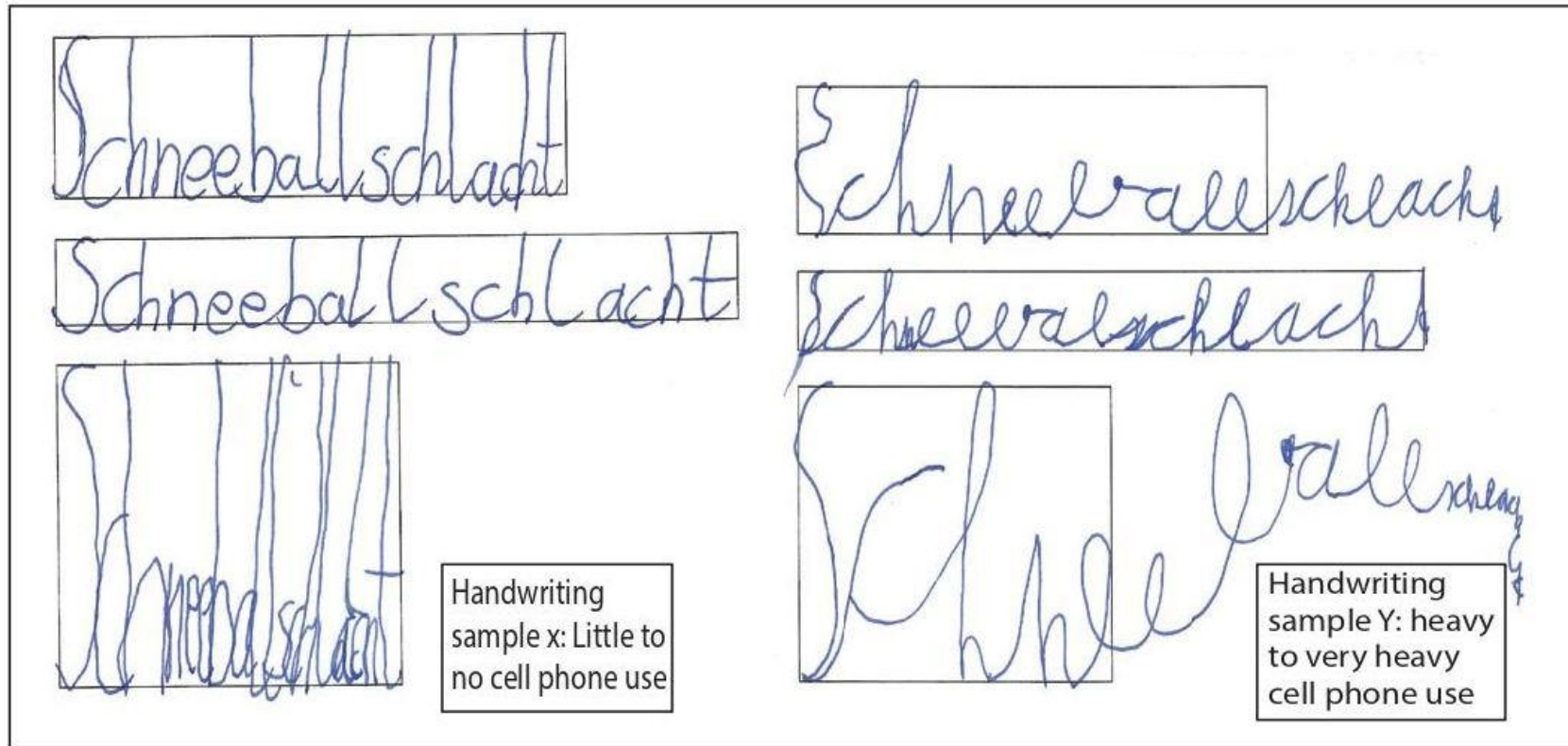
Foerster M, Thielens A, Joseph W, Eeftens M and Röösli M(2018): A Prospective Cohort Study of Adolescents' Memory Performance and Individual Brain Dose of Microwave Radiation from Wireless Communication, Environmental Health Perspectives, Vol. 126, No. 7

Mumbai: Säuglingsstudie 2025 (Setia, 2025)



<https://www.diagnose-funk.org/2256>

Raum-Zeit-Verrechnung



Supper A, Teuchert-Noodt G.
“How learning doesn't work”
Children evaluate their cell
phone use – An empirical pilot
study . Neurol Neurosci. 2021;
1(3):1-9.

Figure. 1a. In this handwriting sample, both students try to fit the word “Schneeballschlacht” [snowball fight] into the assigned rectangle.

Kommunikation von Hirnrhythmen

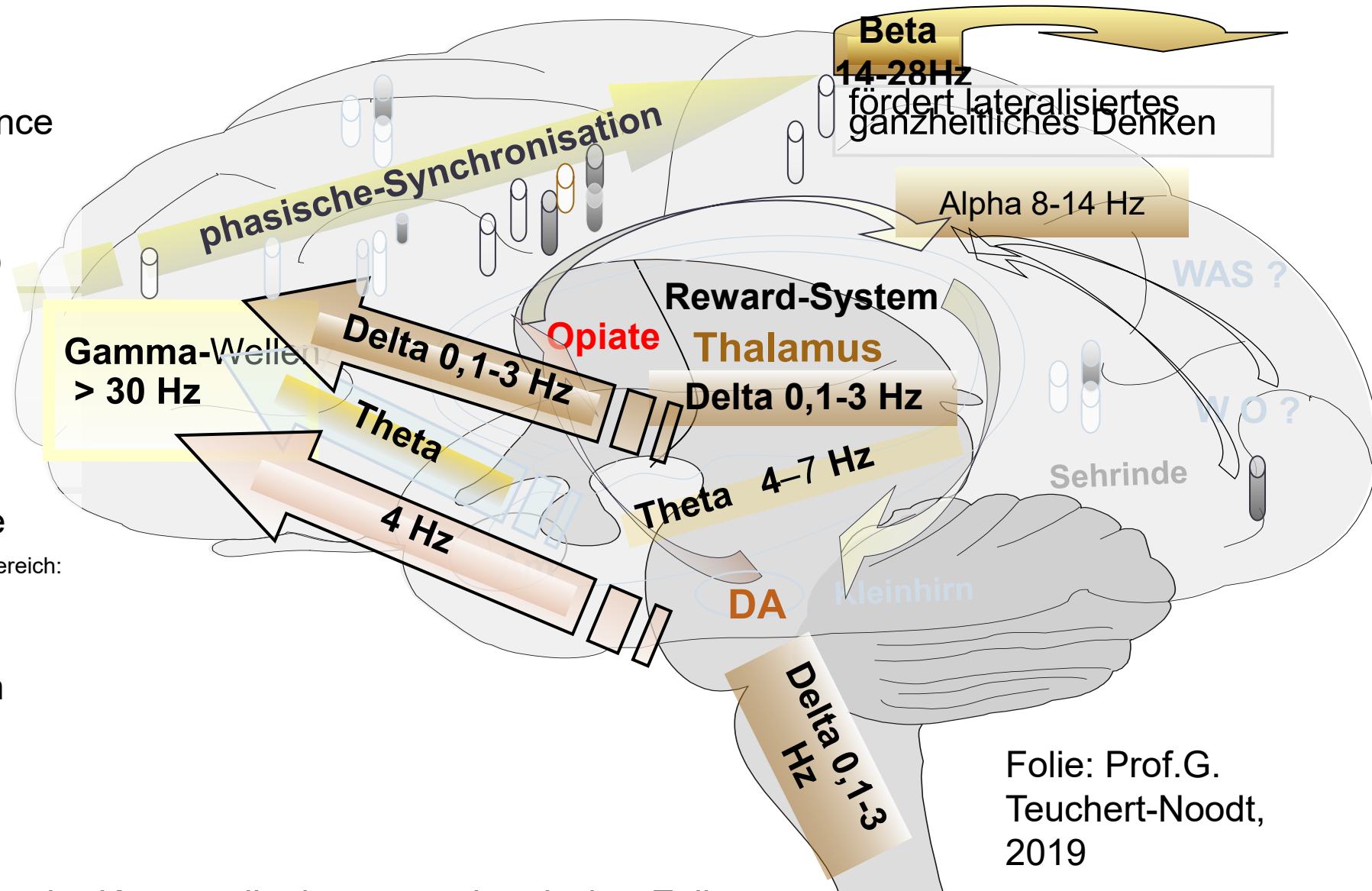
Delta 0,5-4 Hz: Tiefschlaf, Trance

Theta 4-6,5 Hz: Wachträumen, Entspannung, Lernfähigkeit (KZG)

Alpha 8-13 Hz: gute Aufnahmefähigkeit, entspannte nach außen gerichtete Aufmerksamkeit

Beta 15-28 Hz: fundiert-hellwache Aufmerksamkeit /im höheren Frequenz-bereich: Hektik, Stress, sprunghafte Gedankenf.

Gamma 30-70 Hz: hoher Informationsfluss, Konzentration neuronale Reorganisation/ Langzeitgedächtnisbildung



Folie: Prof.G.
Teuchert-Noodt,
2019

Oscillatoren entstehen teilweise aus der Kommunikation neurochemischer Zellprozesse, sie sind rhythmisch aufeinander abgestimmt, interferierende Sequenzen synchronisieren sich.

Hoffmann et al. 2001

Indian Journal of Experimental Biology
Vol. 39, December 2001, pp.1220-1226

Electromagnetic exposure effects the hippocampal dentate cell proliferation in gerbils (*Meriones unguiculatus*)

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Received 11 September, 2000; revised 13 August, 2001

The chronic effect on hippocampal neurogenesis after exposure (30 min/day for 14 days) to a high frequency (35,53 kHz) electromagnetic field, double modulated at extremely low frequencies (ELF; 1, 8, 12, 29 and 50 Hz), was studied in young adult gerbils. Immediately after the last exposure proliferation of dentate granule cells was identified by *in vivo* labeling with 5-bromo-2-desoxyuridine (BrdU). Exposure to 1, 29 and 50 Hz resulted in a statistically significant reduction of cell proliferation rates, but only the 50 Hz-group manifested the effect highly significantly (-29,3 %). On the other hand, gerbils exposed to 8 and 12 Hz showed no significant change of postmitotic cell proliferation as compared with the sham treated controls. The results suggest that the effects of ELF on the granule cell proliferation are mediated by neurotransmitters and hormones which regulate hippocampal neurogenesis.

Biological effects of exposure to magnetic, electric and electromagnetic fields are yet to be adequately investigated. In extremely low frequency (ELF) range, the magnetic and electric components of the field separate and may be expected to act independently on biological systems. As far as

the cholinergic^{8,9}, serotonergic¹⁰ and dopaminergic¹¹ central systems are of vital importance.

Experimental studies on rodents indicated adaptive changes of short-term memory¹² and open field behavior¹³ to ELF exposure-the two patterns in which the limbic system is essentially involved. Behavioural

Hoffmann et al. 2001

Bei 50 Hz sank die Zellneubildung – die Neurogenese – im Hippocampus um fast 30 Prozent.

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Biological effects of exposure to magnetic, electric and electromagnetic fields are yet to be adequately investigated. In extremely low frequency (ELF) range, the magnetic and electric components of the field separate and may be expected to act independently on biological systems. As far as the cholinergic^{8,9}, serotonergic¹⁰ and dopaminergic¹¹ central systems are of vital importance. Experimental studies on rodents indicated adaptive changes of short-term memory¹² and open field behavior¹³ to ELF exposure-the two patterns in which the limbic system is essentially involved. Behavioural

Hoffmann et al. 2001

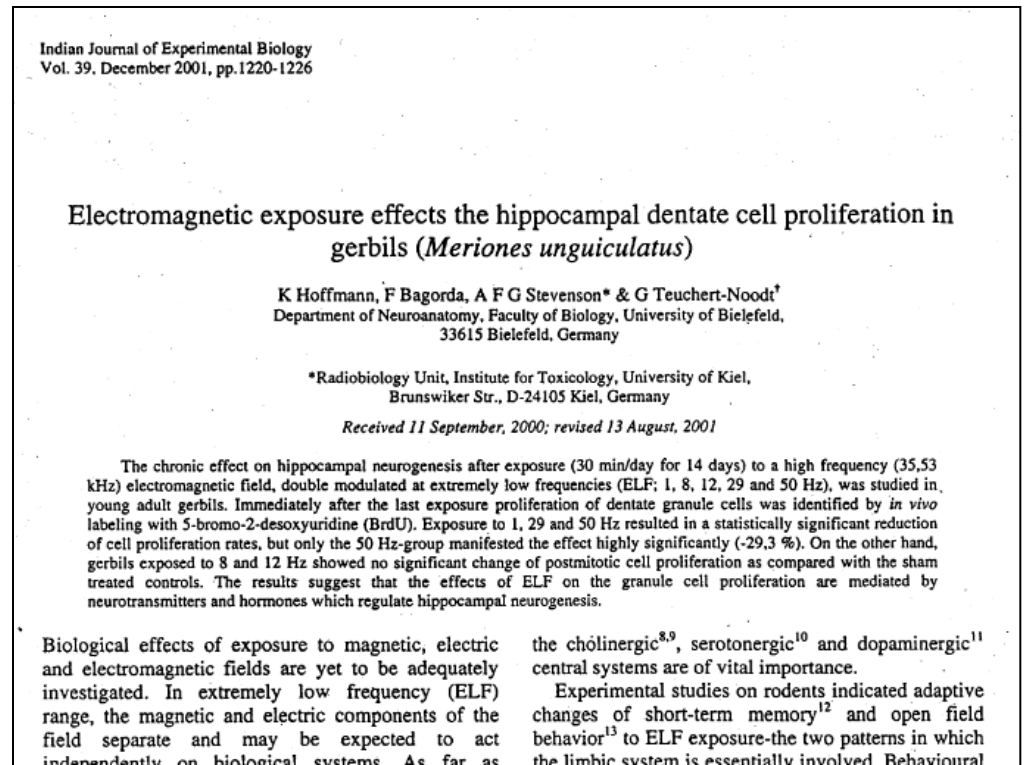
Bei 50 Hz sank die Zellneubildung – die Neurogenese – im Hippocampus um fast 30 Prozent.

EMF-Exposition →

→ veränderte Dopamin- und Melatoninregulation

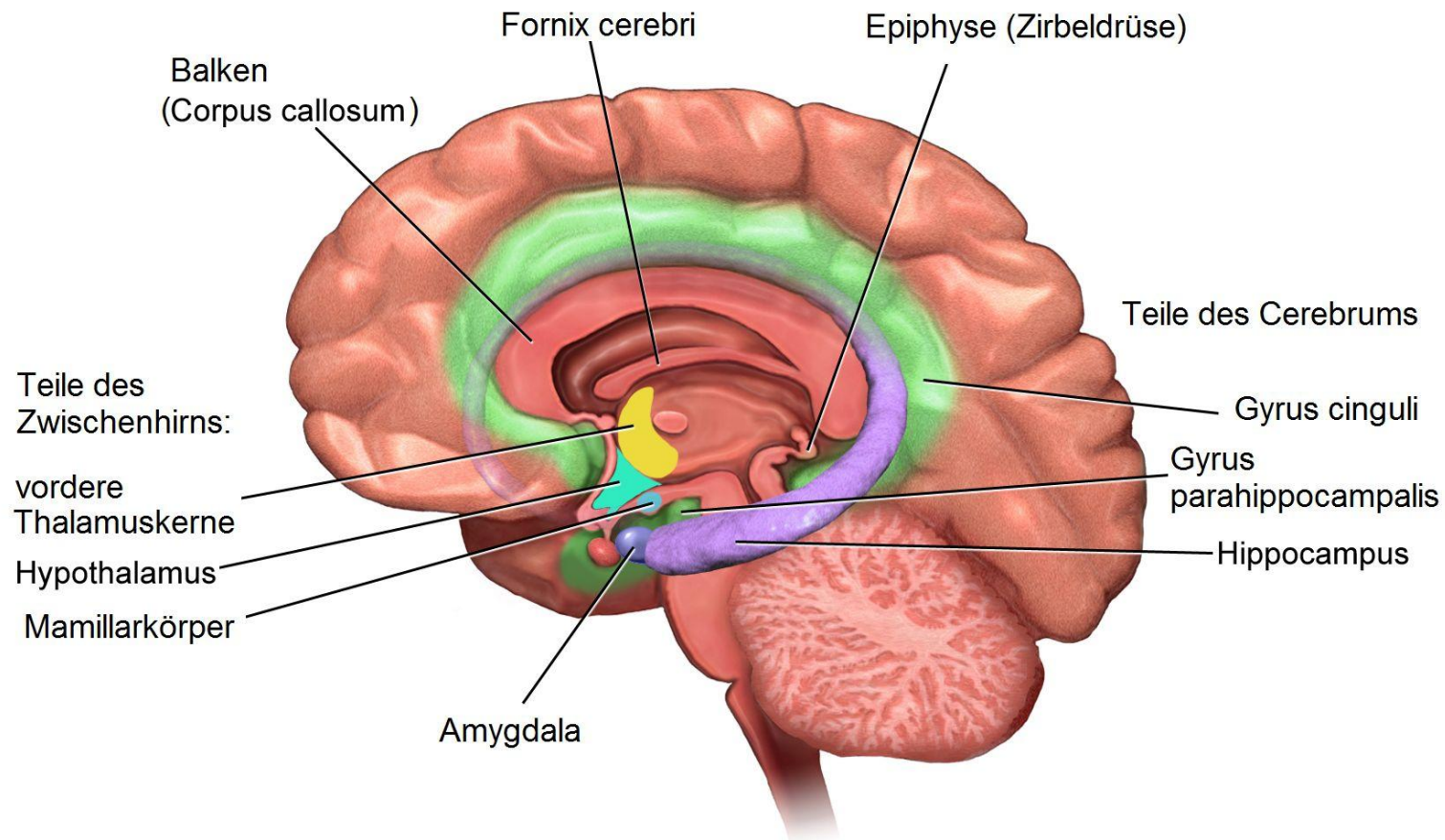
→ Modulation des NMDA-Systems

→ reduzierte Neurogenese und Plastizität im Hippocampus.



Sekretär Hippocampus unter Strahlenstress

Das limbische System



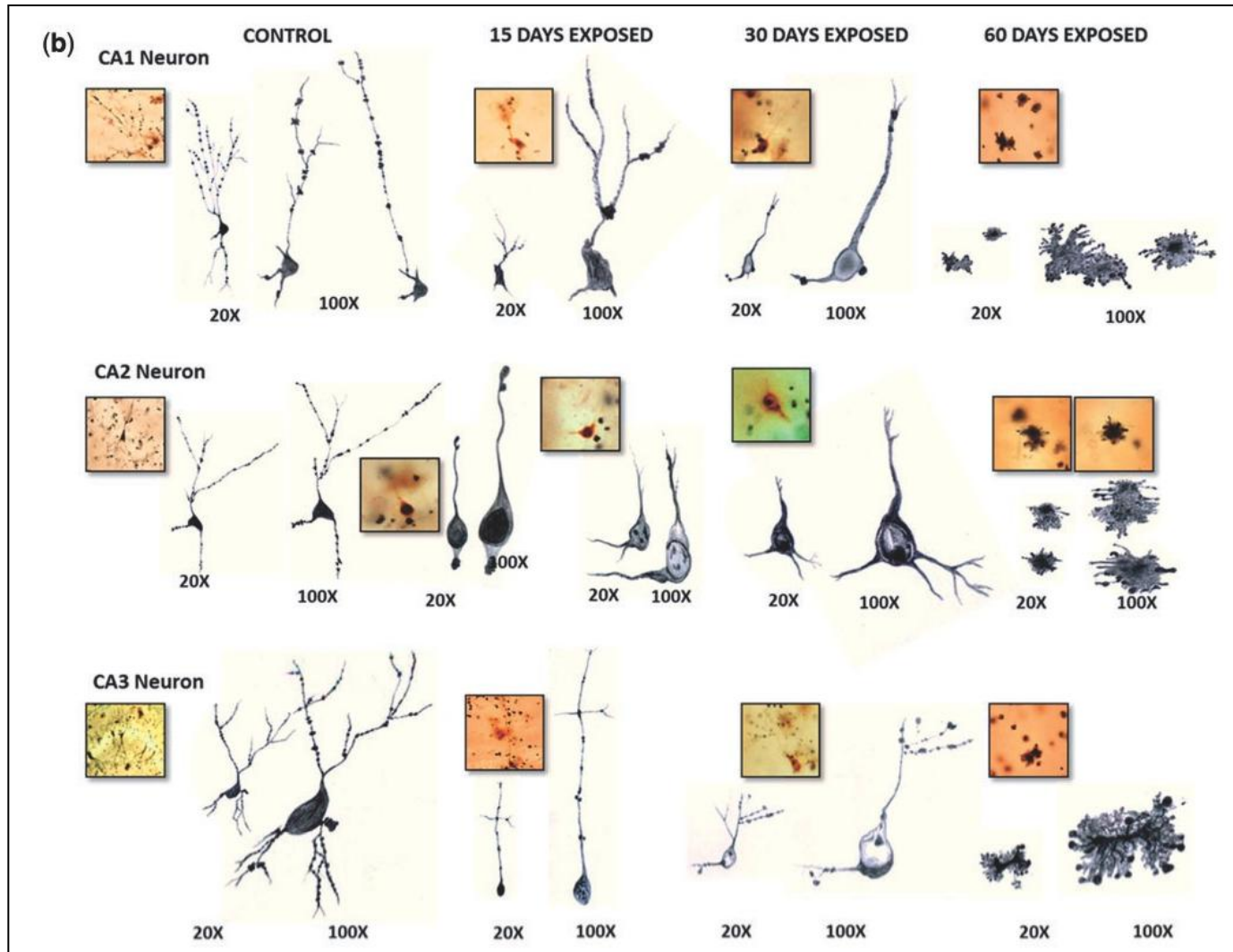
Grafik: Wikipedia

- "(1) Verschlechtertes Lern- und Erinnerungsvermögen bei männlichen erwachsenen Mäusen, welche mit 2,45 GHz Mikrowellen bestrahlt wurden.**
- (2) Erhöhtes **hippocampisches** Stresslevel.**
- (3) Beeinträchtigte **synaptische Plastizität**.**
- (4) Verringerte Expression von Signalkomponenten, welche für **Lern- und Gedächtnisprozesse** von hoher Bedeutung sind. "** (ElektrosmogReport 4/2018)

Shahin S, Banerjee S, Singh SP, Chaturvedi CM (2015): 2.45 GHz Microwave Radiation Impairs Learning and Spatial Memory via Oxidative/Nitrosative Stress Induced p53-Dependent/ Independent Hippocampal Apoptosis: Molecular Basis and Underlying Mechanism. Toxicological Sciences 148 (2), 380–399

Shahin S, Banerjee S, Swarup V, Singh SP, Chaturvedi CM (2018): 2.45-GHz Microwave Radiation Impairs Hippocampal Learning and Spatial Memory: Involvement of Local Stress Mechanism-Induced Suppression of iGluR/ERK/CREB Signaling. Toxicological Sciences 161 (2), 349–374

Gehirnzellen im Hippocampus (Shahin et al. 2015)



Struktur und Form der Neuronen im Hippocampus der bestrahlten Mäuse:

1. „**Anzahl der Dendriten nahm** bei allen exponierten Mäusegruppen zeitabhängig **signifikant ab.**“
2. „Die **Anzahl der absterbenden oder degenerierenden Neuronen stieg** bei den Mäusegruppen, die 30 und 60 Tage lang 2,45 GHz ausgesetzt waren.“
3. „Beachten Sie die **neuronalen Verklumpung oder Verstopfung** bei Mäusen, die 60 Tage lang 2,45 GHz ausgesetzt waren.“
(Übersetzungen d:f)

➔ **Mobilfunkstrahlung kann Gehirnzellen verkümmern lassen.**

Kim et al. (2021, 2024): Hemmung des Düngers BNDF



International Journal of
Molecular Sciences



Article

Exposure to Radiofrequency Induces Synaptic Dysfunction in Cortical Neurons Causing Learning and Memory Alteration in Early Postnatal Mice

Ju Hwan Kim ¹, Jun Young Seok ¹, Yun-Hee Kim ², Hee Jung Kim ³, Jin-Koo Lee ¹ and Hak Rim Kim ^{1,*}

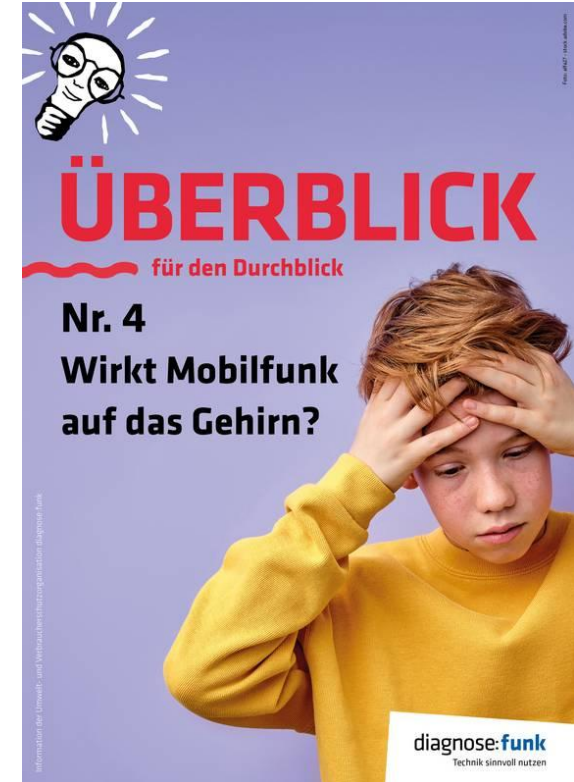
¹ Department of Pharmacology, College of Medicine, Dankook University, Cheonan 31116, Republic of Korea; jhkim731@dankook.ac.kr (J.H.K.); seogant95@naver.com (J.Y.S.); leejking@dankook.ac.kr (J.-K.L.)

² Department of Biology Education, Institute of Agriculture and Life Science (IALS), Gyeongsang National University, Jinju 52609, Republic of Korea; cefle@gnu.ac.kr

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* Correspondence: hrkim@dankook.ac.kr; Tel.: +82-41-550-3935

Abstract: The widespread use of wireless communication devices has necessitated unavoidable expo-



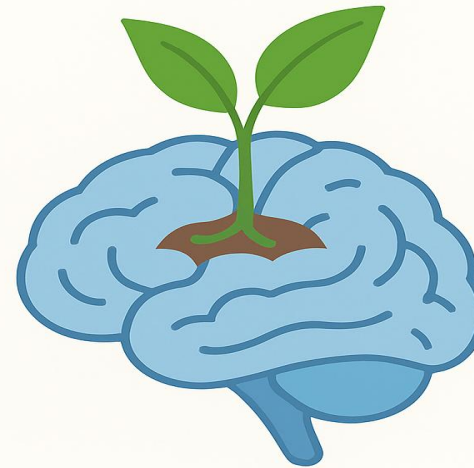
BDNF (Brain-Derived Neurotrophic Factor)



Vom Gehirn stammender neurotropher Faktor

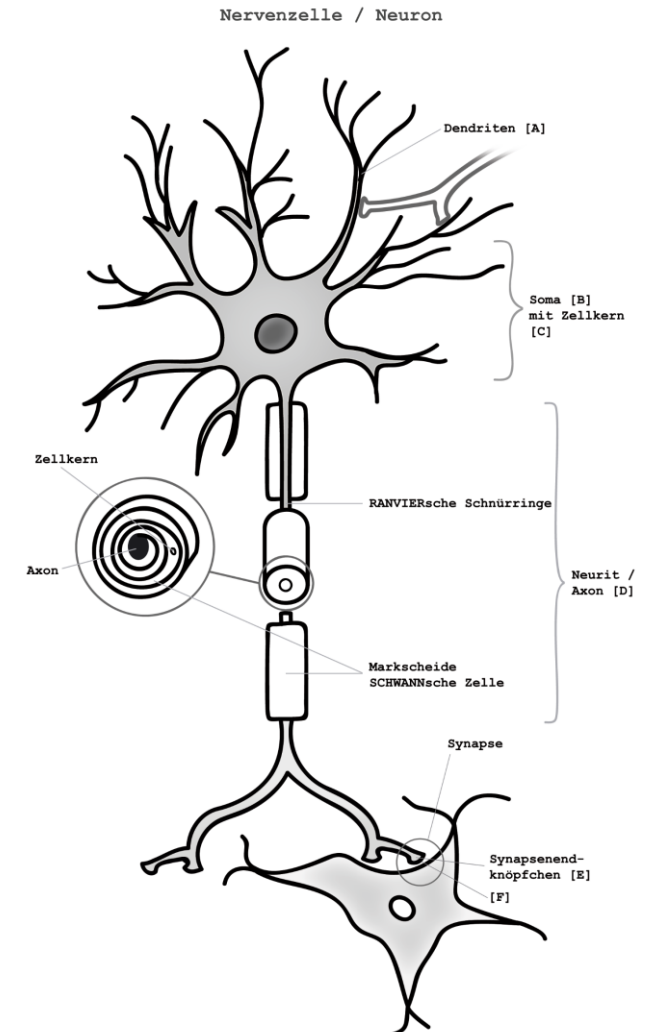
BDNF – Der Dünger des Gehirns

Funktion und Bedeutung für
die Gehirn- und
Synapsenentwicklung



Dünger des Gehirns: Brain Derived Neurotrophic Faktor

- Reduzierte Expression des **BDNF** (Brain Derived Neurotrophic Faktor), ein Wachstumsfaktor, der wie ein Dünger z. B. für das Neuronenwachstum wirkt.
- Eine deutliche Abnahme der **Glutamatrezeptoren NMDA und AMPA**, die für die Plastizität der neuronalen Signalübertragung verantwortlich sind.
- Verminderte Anzahl dendritischer Dornen, also der Kontaktstellen für synaptische Übertragung.

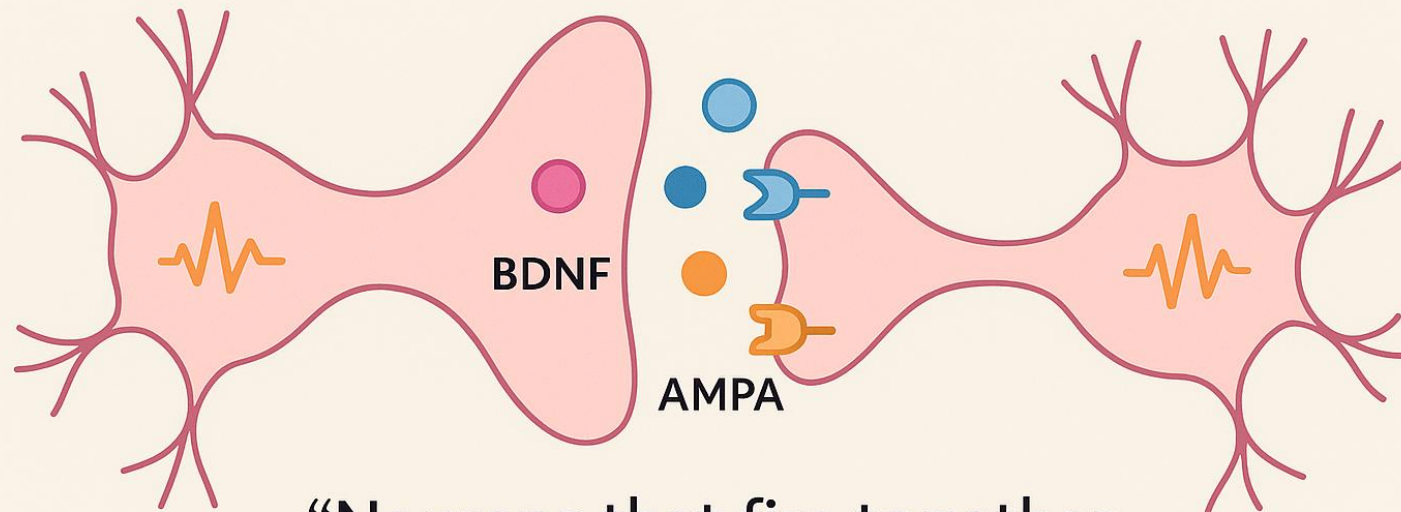


Hebbsche Lernsynapse



HEBB'S LEARNING SYNAPSE

Central to associative learning



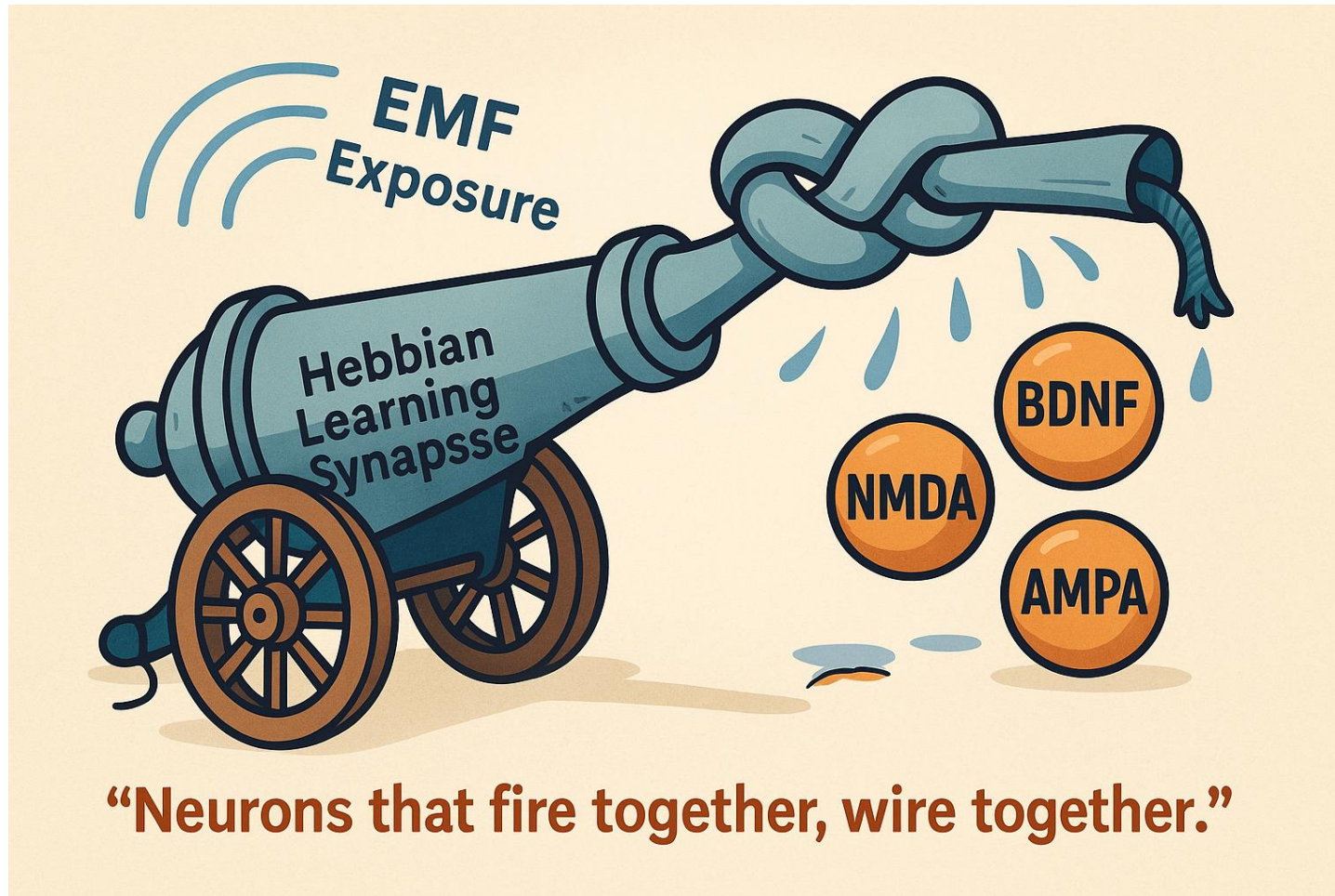
“Neurons that fire together,
wire together.”

– Donald Hebb, 1949

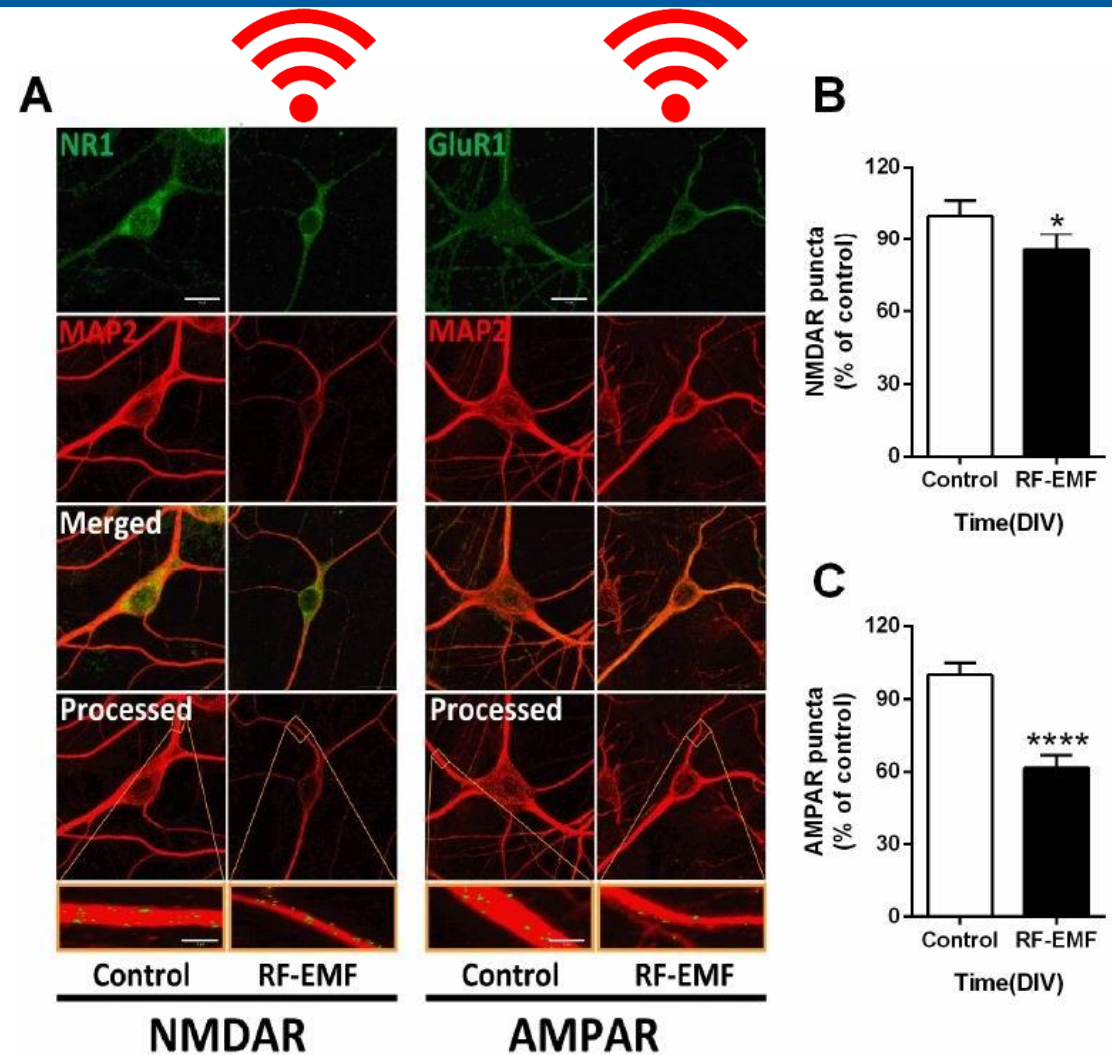
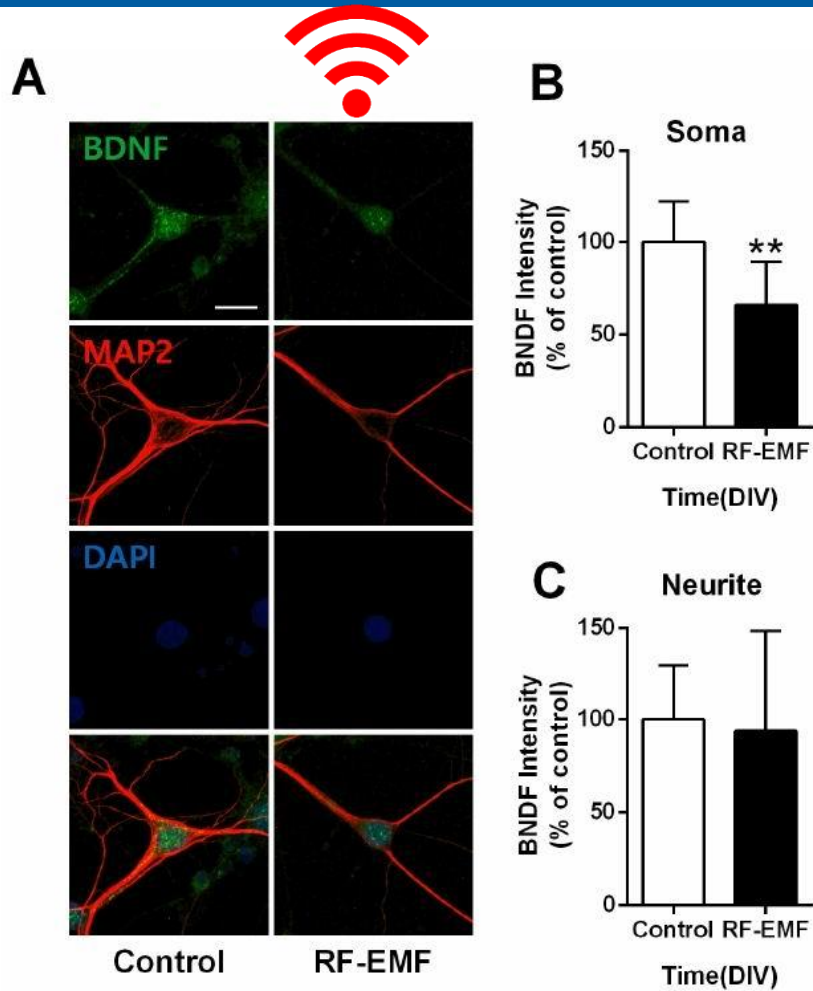
● BDNF ● NMDA ● AMPA

**BDNF, NMDA
und AMPA
triggern die
Hebb'schen
Lernsynapsen**

Hebbsche Lernsynapse


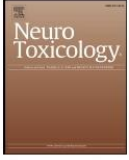


Abnahme von BDNF, NMDA und AMPA – Gehirndünger und Trigger der Lernsynapsen (Kim et al. 2021)




Bodin et al. 2025

Contents lists available at [ScienceDirect](#)

 Neurotoxicology 

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



Altered development in rodent brain cells after 900 MHz radiofrequency exposure

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Synaptogenesis
Neuroproteomics
Neurodevelopment
Neurotoxicology

ABSTRACT

Health risks related to 900 MHz 2 G frequency exposure remain inconclusive under current regulatory standards. Research into potential long-term effects is ongoing, particularly as the use of mobile networks and wireless devices increases. This study investigates the effects of non-thermal exposure levels of mobile phone 900 MHz radiofrequency electromagnetic field (RF-EMF) on rodent neurodevelopment. *In vivo*, the effects of pre- and post-natal 0.08 and 0.4 W/kg specific absorption rate (SAR) exposure were assessed for their impact on the proteomic profile at postnatal day 0 (PND 0). Brain-derived neurotrophic factor (BDNF), BrdU+ proliferative cells, syn-

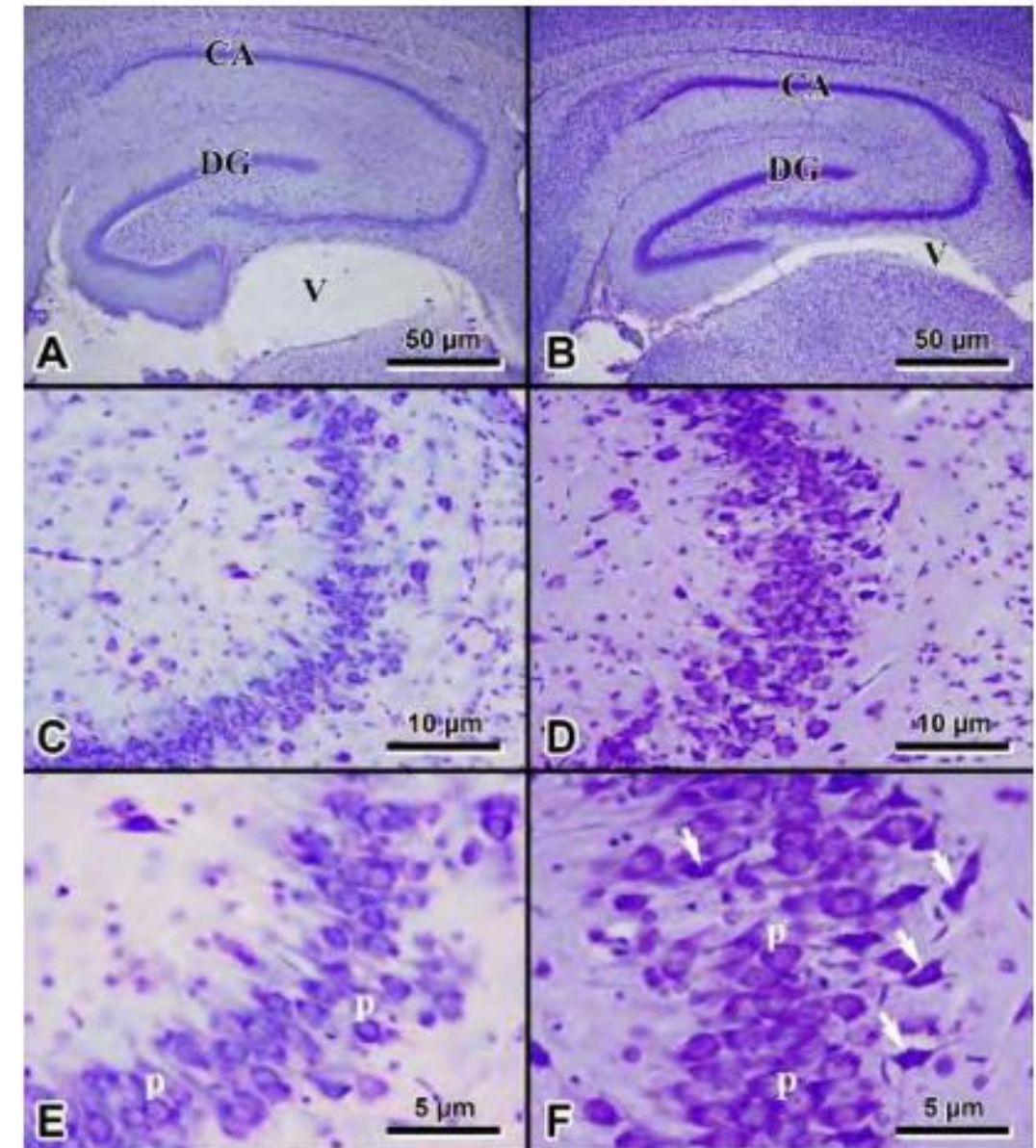
Die „In-vivo-Ergebnisse zeigten eine Abnahme des BDNF-Spiegels“.

Odaci et al. 2008

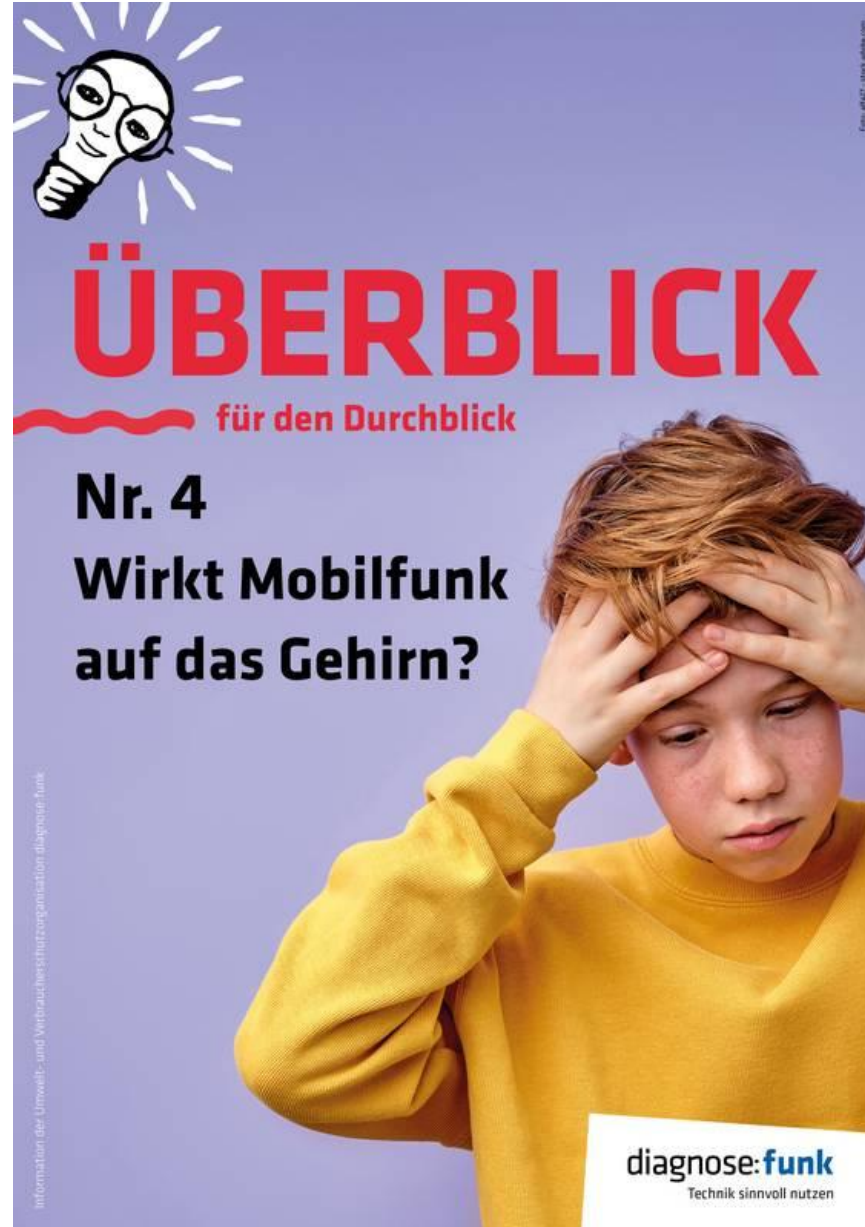
Die pränatale Exposition bei elektromagnetischen Feldern bewirkte im Vergleich zur Kontrollgruppe ein Absinken der Anzahl der Körnerzellen im Gyrus dentatus der Ratten.

Diese Studie untersuchte die Wirkung einer pränatalen Exposition bei elektromagnetischen Feldern auf die Anzahl von Körnerzellen im Gyrus dentatus von Ratten. Die Produktion und Plastizität von neuen Neuronen im Gyrus dentatus ist wichtig für Hippocampus-Funktionen.

Odaci E, Bas O, Kaplan S. Effects of prenatal exposure to a 900 MHz electromagnetic field on the dentate gyrus of rats: a stereological and histopathological study. *Brain Res* 2008; 1238 : 224 - 229



Dokumentation von 50 Studien



ÜBERBLICK
für den Durchblick

Nr. 4
Wirkt Mobilfunk
auf das Gehirn?

Information der Umwelt-, und Verbraucherschutzorganisation diagnose:funk

diagnose:funk
Technik sinnvoll nutzen

Foto: iStock - iStockphoto.com

Hu et al. (2021)

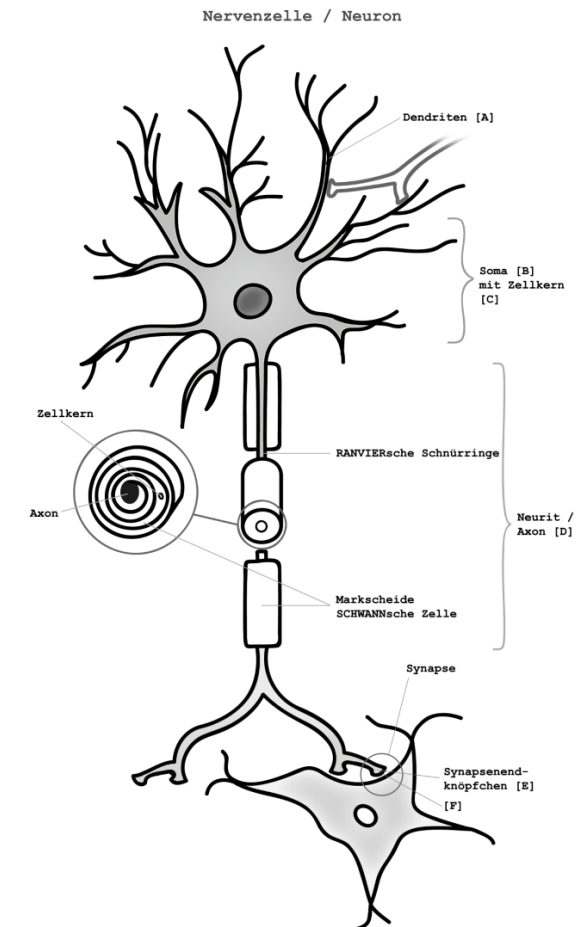


Effects of Radiofrequency Electromagnetic Radiation on Neurotransmitters in the Brain

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¹Anhui Medical University, Academy of Life Sciences, Hefei, China, ²Department of Experimental Pathology, Beijing Institute of Radiation Medicine, Beijing, China

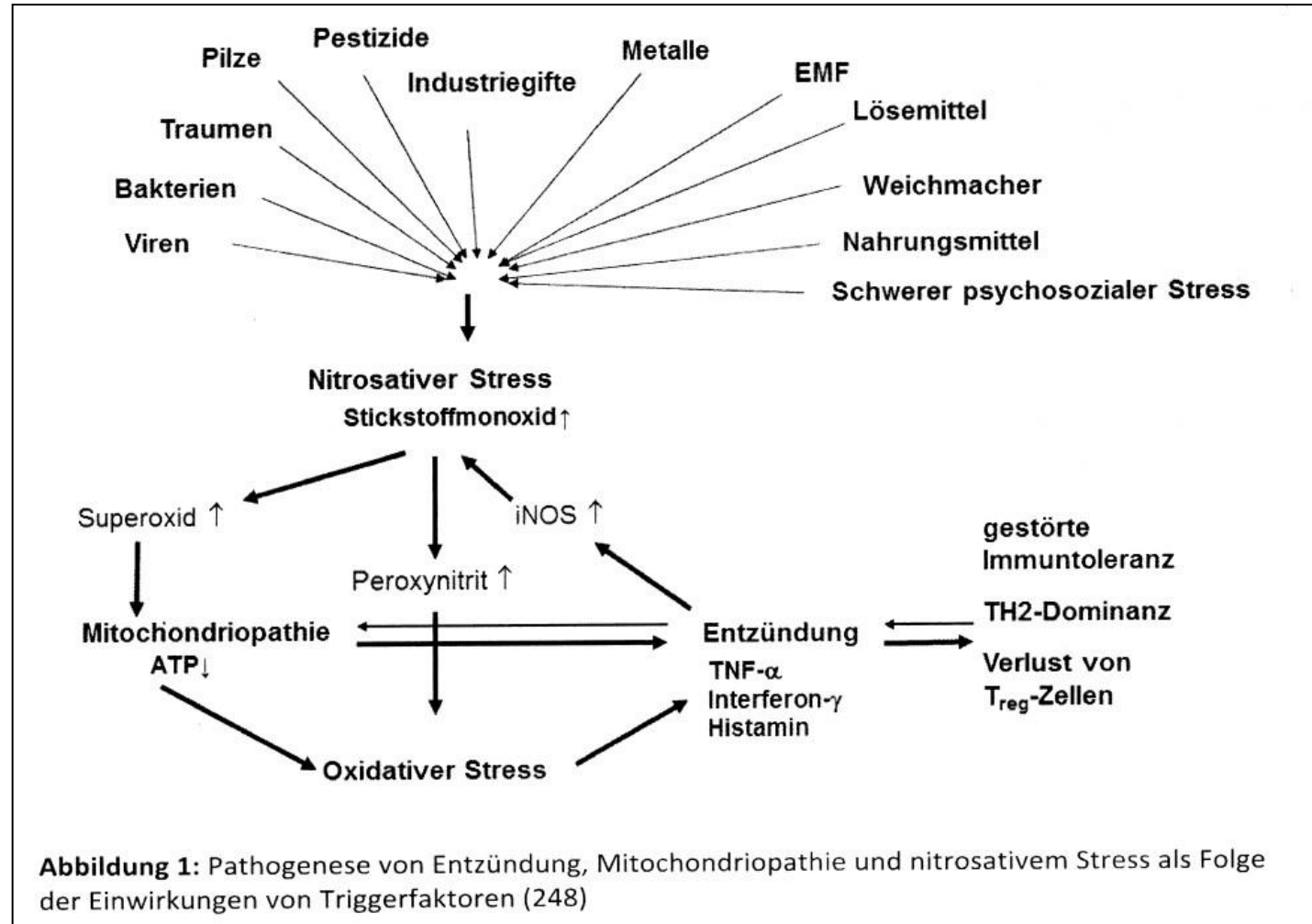
With the rapid development of electronic information in the past 30 years, technical achievements based on electromagnetism have been widely used in various fields pertaining to human production and life. Consequently, electromagnetic radiation (EMR) has become a substantial new pollution source in modern civilization. The biological effects of EMR have attracted considerable attention worldwide. The possible interaction of EMR with human organs, especially the brain, is currently where the most attention



Hu et al. (2021)

- 1. Neurotransmitter-Ungleichgewicht, also eine biochemische Dysregulation**
- 2. Oxidativem Stress und Apoptose, also zellulären Schädigungen**
- 3. Verhaltens- und Gedächtnisveränderungen, also funktionellen Folgen**

EMF führt zu oxidativem Zellstress



Grafik: von Baehr, umg, 2012

Schuermann / Mevissen 2021

 International Journal of
Molecular Sciences 

Review
**Manmade Electromagnetic Fields and Oxidative Stress—
Biological Effects and Consequences for Health**

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* Correspondence: david.schuermann@unibas.ch (D.S.); meike.mevissen@vetsuisse.unibe.ch (M.M.)

Abstract: Concomitant with the ever-expanding use of electrical appliances and mobile communication systems, public and occupational exposure to electromagnetic fields (EMF) in the extremely-low-frequency and radiofrequency range has become a widely debated environmental risk factor for health. Radiofrequency (RF) EMF and extremely-low-frequency (ELF) MF have been classified as possibly carcinogenic to humans (Group 2B) by the International Agency for Research on Cancer (IARC). The production of reactive oxygen species (ROS), potentially leading to cellular or systemic oxidative stress, was frequently found to be influenced by EMF exposure in animals and cells. In this review, we summarize key experimental findings on oxidative stress related to EMF exposure from animal and cell studies of the last decade. The observations are discussed in the context of molecular mechanisms and functionalities relevant to health such as neurological function, genome stability, immune response, and reproduction. Most animal and many cell studies showed increased oxidative stress caused by RF-EMF and ELF-MF. In order to estimate the risk for human health by manmade exposure, experimental studies in humans and epidemiological studies need to be considered as well.

Keywords: oxidative stress; ROS; electromagnetic field; extremely low frequency; radiofrequency; environment and public health; environmental exposure; animal study; cultured cells

1. Introduction

Reactive oxygen species (ROS), as well as related reactive nitrogen species (RNS), are involved in many biological processes; nonetheless, they pose a hazard to the biological material and physiology of cells [1–3]. Protective mechanisms, such as antioxidants and antioxidative enzymes, maintain physiological concentrations of ROS in cells, while external and internal stimuli affect the amount of ROS by altering the activity of involved ROS-forming and -degrading enzymes [4]. For example, an increased energy requirement during physical activity leads to a temporary state of oxidative stress, and many environmental risk factors such as ionizing radiation in ultraviolet (UV) light or the radioactivity spectrum partly act via the formation of ROS. Pathophysiological levels of ROS interfere with many vital cellular processes and functions, such as inflammation, cell proliferation and differentiation, wound healing, neuronal activity, reproduction, and behavior by altering biochemical and signaling processes or even resulting in oxidative damage to DNA, RNA, and proteins or to the peroxidation of fatty acids [5,6]. If this unfavorable state persists over a long period or occurs repeatedly, it can lead to changes in the biological material, as well as the genetic and epigenetic information, and it can lead to health-related malfunctions. Accordingly, altered ROS levels and changes in biomarkers of oxidative stress as cause or consequence have been observed in many diseases, such as cancer, diabetes, congenital malformations, or neurodegenerative syndromes [1,3].

The influence of electromagnetic fields (EMF), as a manmade environmental factor with increasing importance, on ROS formation, triggering oxidative stress, has been repeatedly discussed. Corresponding hypotheses and experimental findings have been

 check for updates

Citation: Schuermann, D.; Mevissen, M. Manmade Electromagnetic Fields and Oxidative Stress—Biological Effects and Consequences for Health. *Int. J. Mol. Sci.* **2021**, *22*, 3772. <https://doi.org/10.3390/ijms22073772>

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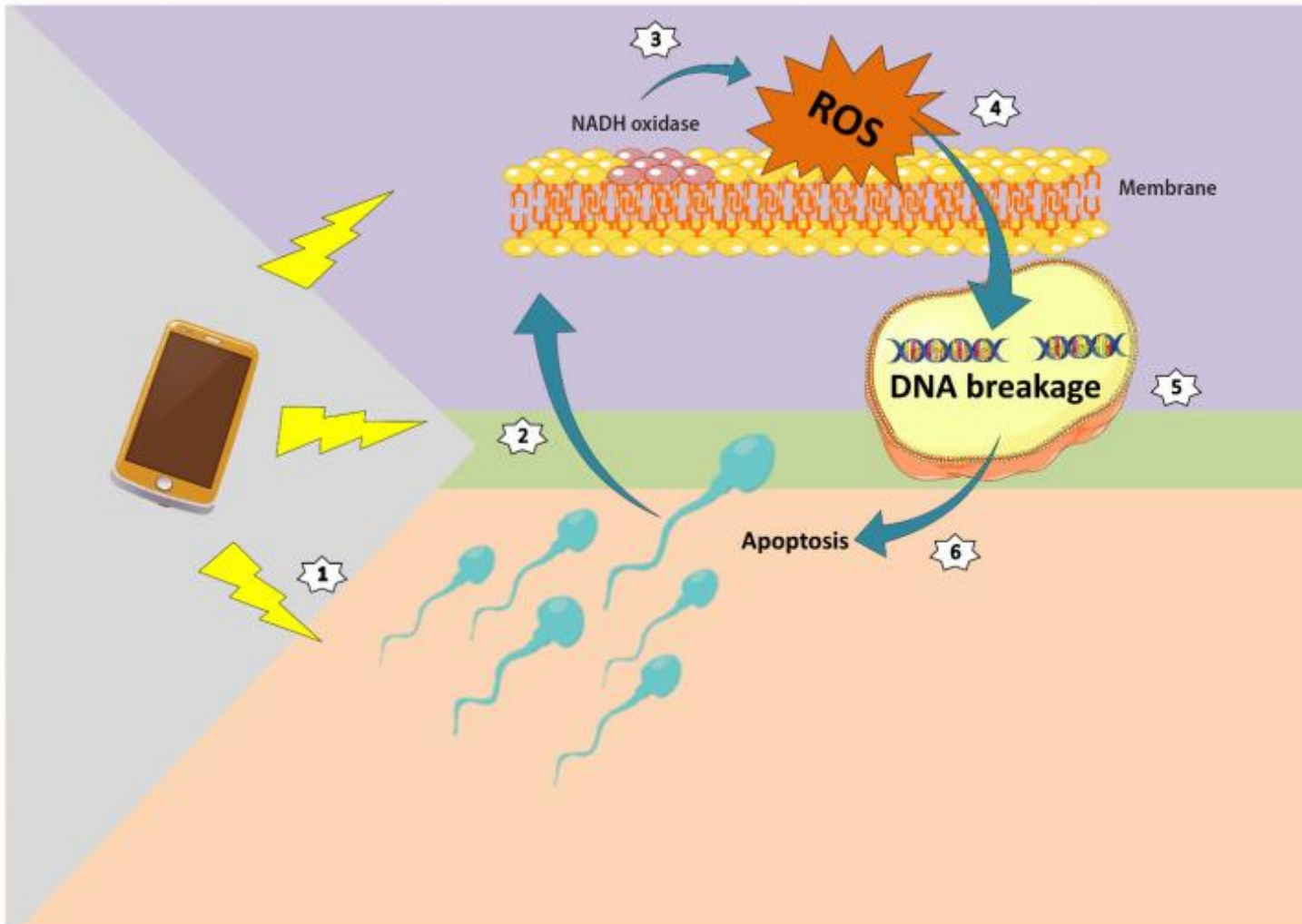
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Int. J. Mol. Sci. **2021**, *22*, 3772. <https://doi.org/10.3390/ijms22073772> <https://www.mdpi.com/journal/ijms>

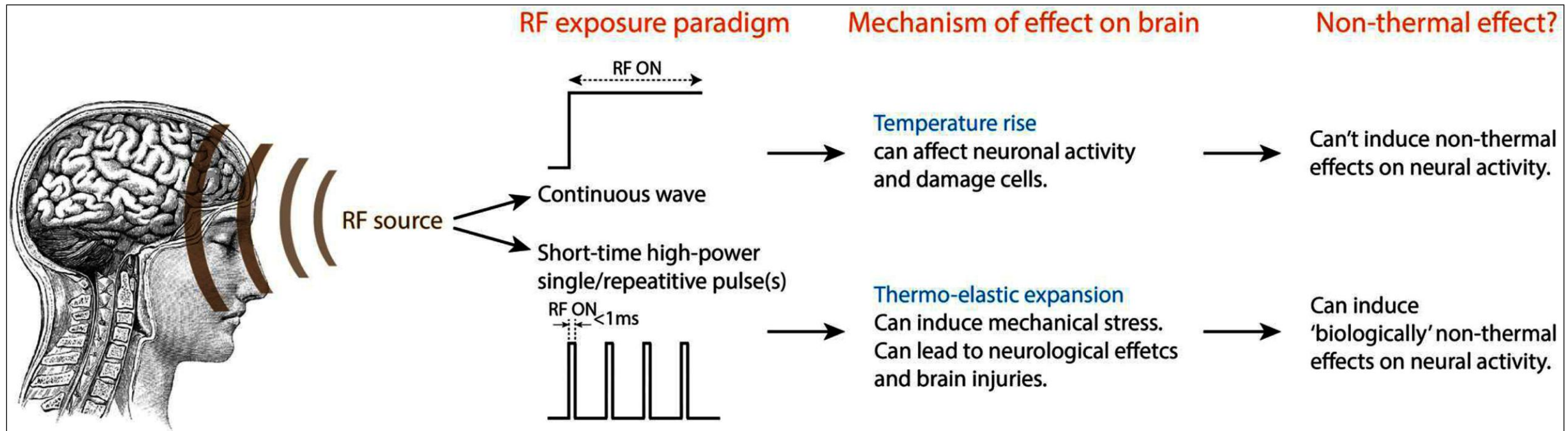
„Zusammenfassend kann gesagt werden, dass die Mehrzahl der Tierstudien und mehr als die Hälfte der Zellstudien Hinweise auf vermehrten oxidativen Stress durch HF-EMF und NF-MF gibt ...“

EMF führt zu oxidativem Zellstress



Grafik aus: Seify M, Khalili MA, Anbari F, Koohestanidehaghi Y (2023): Detrimental effects of electromagnetic radiation emitted from cell phone on embryo morphokinetics and blastocyst viability in mice, *Zygote* 2024: 1-5

Überblicksstudie 2024 im IEEE - Journal



Omid Yaghmazadeh (2024): Pulsed High-Power Radio Frequency Energy Can Cause Non-Thermal Harmful Effects on the BRAIN, IEEE Open Journal of Engineering of Medicine and Biology.

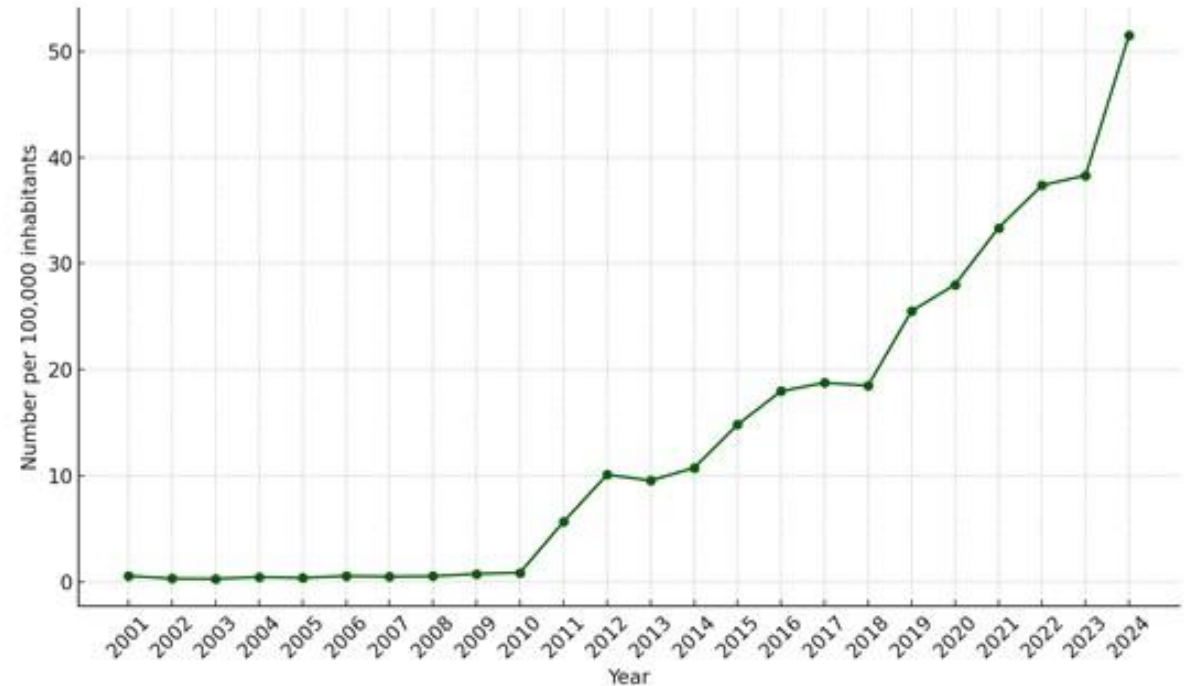
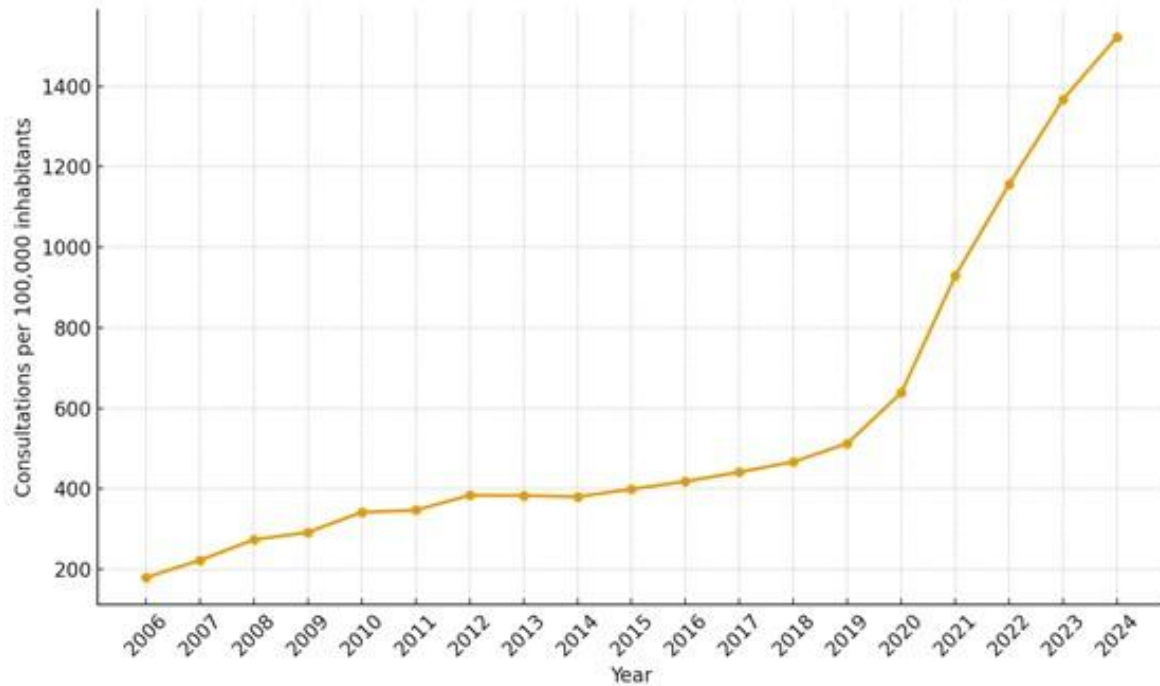


Abbildung links: **Anzahl der Konsultationen wegen Gedächtnisproblemen** (ICPC-2-Code P20) bei Kindern im Alter von 5 bis 19 Jahren pro 100.000 Einwohner in **Norwegen** im Zeitraum 2006–2024.
Abbildung rechts: Anzahl der Patienten im Alter von 5 bis 19 Jahren pro 100.000 Einwohner pro Jahr mit R41.8 **„leichte kognitive Beeinträchtigung, subjektiv“** als Hauptdiagnose in **Schweden** im Zeitraum 2001–2024.



„Je länger sich Kinder und Jugendliche in ihrer Freizeit mit ihren Smartphones beschäftigen und je mehr Zeit sie in sozialen Medien verbringen, desto geringer ist die schulische Lernleistung.“

„Kinder und Jugendliche brauchen mehr denn je Zeit und Raum für Spiel, Sport und Bewegung.“



"Wir empfehlen, die Nutzung von Smartphones in Kitas und Schulen bis einschließlich Klasse 10 zu untersagen."

Herunterladen : diagnose-funk/2029



ÜBERBLICK
für den Durchblick

Nr. 7
Kinder und digitale Medien

Eine pädagogische Herausforderung!

Information der Umwelt- und Verbraucherschutzorganisation diagnose:funk

diagnose:funk
Technik sinnvoll nutzen



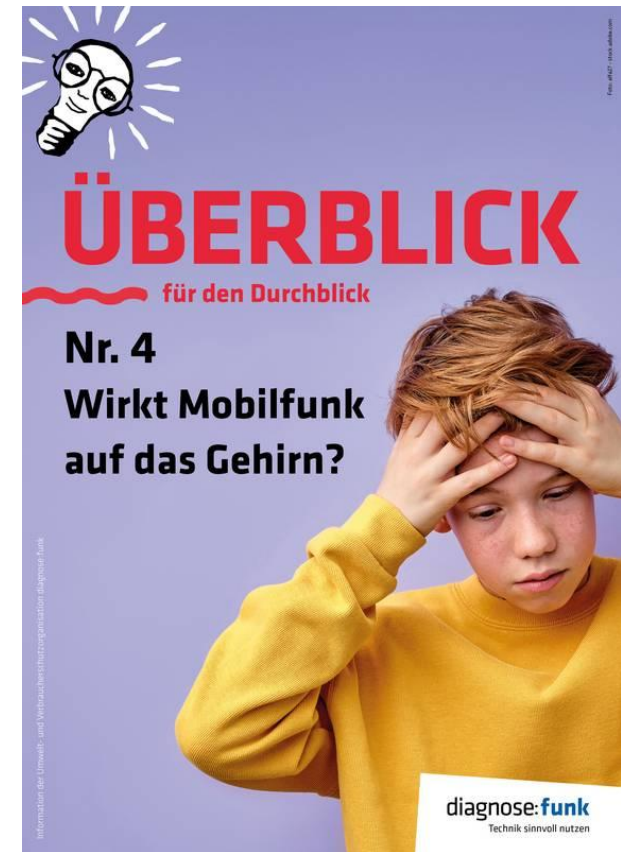
ÜBERBLICK
für den Durchblick

Nr. 9
Digitale Bildung

Ausweg aus der Bildungskatastrophe?

Information der Umwelt- und Verbraucherschutzorganisation diagnose:funk

diagnose:funk
Technik sinnvoll nutzen



ÜBERBLICK
für den Durchblick

Nr. 4
Wirkt Mobilfunk auf das Gehirn?

Information der Umwelt- und Verbraucherschutzorganisation diagnose:funk

diagnose:funk
Technik sinnvoll nutzen

Bestellung im diagnose:funk Shop

Ratgeber 5
**KINDER UND JUGENDLICHE
IN DIGITALEN ZEITEN -
STARK UND SELBSTBESTIMMT**

So fördern Sie die gesunde
Entwicklung Ihres Kindes

Starke Kinder
haben eigene
Ideen – auch ohne
Smartphone!

Information der Umwelt- und Verbraucherschutzorganisation diagnose:funk

diagnose:funk
Technik sinnvoll nutzen

Michaela Glöckler (Hrsg.)
**GESUND AUFWACHSEN
IN DER DIGITALEN
MEDIENWELT**

Eine Orientierungshilfe für Eltern und
alle, die Kinder und Jugendliche begleiten

diagnose:media

**WLAN AN
SCHULEN?**

Studien belegen: WLAN-Strahlung ist gesundheitsschädlich. Es gibt Alternativen!

Tipps zum Schutz von Kindern und Lehrer*innen

diagnose:funk

**Aufwach(s)en im Umgang
mit digitalen Medien**

Was Eltern und Erzieher wissen sollten:
Wie der Gebrauch digitaler Medien
die Gehirnentwicklung beeinflusst

Regie:
Klaus Scheidsteger
Drehbuch:
Gertraud Teuchert-Noodt
Peter Hensinger
Klaus Scheidsteger

diagnose:funk

Kurzvideo für Elternabende
<https://kurzlinks.de/sn8k>



Vielen Dank für Ihre Aufmerksamkeit!



Ratgeber 5

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diagnose:funk
Technik sinnvoll nutzen

A photograph of a group of children playing in a grassy field. They are holding a long stick or rope, possibly playing a game. The background shows trees and a clear sky.

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