"Ionic currents through Ca²⁺ channels in mature mouse inner hair cells under mobile phone field exposure"

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Hearing and mobil phone communication



- mobile phone in close proximity to the ear.
- relatively small numbers of investigations with respect to the hearing system.

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Overview over the peripheral hearing system



- Abb.15-4abs Schmidt/ Thews: Hysiologie des Menschen 27. Ablage 1997
- outer ear: sound guidance/sound localisation.
- middle ear: impedence transformation.
- inner ear: sound analysis/transformation of sound into neural signals.

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Traveling wave & frequency analysis



Abb. 15-5 aus Schmidt/Thews: Physiologie des Menschen 27. Auflage 1997

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Traveling wave & frequency analysis



- traveling wave \leftrightarrow frequency-place-mapping.
- outer hair cells in the organ von corti actively amplify of the traveling wave.

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Organ of Corti



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Traveling wave & frequency analysis



- inner hair cells (IHCs) transform the sound into neural signals.
- outer hair cells (OHCs) actively amplify the traveling wave.

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Inner hair cells



- deflection of stereocilia opens mechanically sensitive transduction channels.
- K⁺-influx depolarises the cell.
- Ca²⁺-influx via
 voltage-activated
 Ca²⁺-channels triggers
 exocytosis of
 neuro-transmitter.
 - voltage-activated K⁺-channels repolarise the cell.

The voltage-activated Ca²⁺-channels plays an essential role in the signal transduction process!

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Patch-clamp recordings of ionic currents through Ca²⁺-channels

- patch-clamp recordings in IHCs of acutely explanted organs of Corti from mature mice (P18±2).
- recordings during 5 min. pre-exposure phase, during 20 min. exposure phase and during a 10-15 min. post-exposure phase.
- three different radio frequency field types simulating UMTS, GSM1800 and GSM900 (still in progress) mobile communication signals were used
- recordings under field intensities corresponding to SAR-values of: 0.02 W/kg, 0.2 W/kg, 2 W/kg, 20 W/kg averaged over the solution volume. A sham exposure was additionally used.
- exposure was randomised and blinded.

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Exposure system



- developed by V. Hansen and J. Streckert, Wuppertal University.
- designed to cause as little as possible additional constraints for the recordings.
- designed as wave-guides with a fin-line structure, field is concentrated in the slot between two thin fins.
- due to the small dimensions of the preparation under the microscope, measurements of the field distribution near the specimen are impossible

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Field distribution

- field distributions were investigated using finite-difference time-domain computations supplemented by measurements within the wave-guides
- temperature was monitored using a metal-free Fabry-Perot-interferometric sensor.



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Patch-clamp recordings



- a small glas pipette (approx. 1 μm tip diameter) is attached to the cell membrane.
- An electrically tight "seal" forms (≈ 10⁹Ω resistance, "giga-seal").
- by appliying small negative pressure the cell-membrane is ruptured and the whole-cell current through the cell-membrane can be recorded.

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Preparation



- acutely isolated organ of Corti of NMRI-mice.
- cells are approached using positive pressure as in a slice-preparation, no supporting cells are removed.
- Ba²⁺ is used as a charge carrier, which together with intracellular Cs⁺ and extracellular TEA and 4-AP blocks K⁺-channels.
- under these conditions recording times of 40 minutes are possible.

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Cross-talk of the exposure system



- present regardless of whether pipette was in contact with the cell or even the solution (open circuit)
- exists only if EM-field is modulated (not present for constant wave).
- possible reason: small non-linearities in the head stage of the patch-clamp amplifier.
- solution: modification of the head-stage.

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Cross-talk — Solution







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Data so far

- data sampling for GSM900 is still in progress
- data for GSM1800 and UMTS is recorded, raw data was analysed and statistical analysis is in progress
- data is as yet not fully unblinded
- data is statistically analysed by Dr. R. Vonthein, Insitut für Biometrie, Tübingen University

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1ms



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