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An overview of experimental clinical studies in BCI shows that non-invasive BCIs using various EEG measures is extremly useful and efficient for brain communication in locked-in patients, particularly with amyotrophic lateral sclerosis. First attems to apply BCI for communicating with the completely locked in and vegetative state are promising but inconclusive. A new approach using classical conditioning of brain responses for the completely locked in is demonstrated.
Considerable progress was made in movement reconstruction with BCI in chronic stroke without redidual movement. An EEG-MEG based BCI system using several robotic devices for hand and arm movement and sensorimotor rhythm (SMR} as the guiding signal for the neuroprosthetic device showed significant recovery of arm and hand movement in one third of the patients but difficulties of generalisation to real life. New approaches adding functional electrical stimulation of hand muscles and tDCS for learning are introduced.
Finally metabolic BCI with real time functional magnetic resonance imaging (rt-fMRI) and Near Infrared Spectroscopy (NIRS)BCI has shown considerable success for the control of schizophrenic symptom sand
criminal psychopathy. However long-term improvement was demonstrated only in Attention deficit Disorder and itractable focal epilepsy using neurofeedback of slow cortical brain potential as BCI.
Supported by the Deutsche Forschungsgemeinschaft(D FG), BMBF, EU (ERC grant)

# Panel Session 3 - Neurological Long Term Rehabilitation in TBI

**3.1**
**Introductory comments to Neurorehabilitation after TBI: Biomechanics on TBI**

***W. Struhal***[1], *F Gerstenbrand*[2];
[1]*Neurological Dept.of the LKH Linz, Linz, Austria,* [2]*Karl Landsteiner Institute for Neurorehabilitation and Space Neurology, Vienna, Austria.*

Understanding the biomechanic aspects in relation to traumatic brain injury simplifies the comprehension of lesion development. Two basic physical factors play an important biomechanic role, the speed v and the acceleration b (b = v2/2s), where s is the deceleration distance. At constant speed of v, b can change to a great extent, if the deceleration distance becomes very small. In the impact moment, the head bone undergoes an elastic deformation. Only if this force in combination with the form of object exceeds the rather individual breaking strength of the skull bone fracture occurs. Location of structure is dependent mostly on the form of impact. At the impact pole and at the counter pole damages occur on the brain surface. Typical pattern of lesions might be identified dependent on the direction of the impact on the head. A common concept to understand occurring patterns is to distinguish between linear brain injury (Grcevic) and/or rotational trauma (Pudenz - Shelden). Usually a combination of both exists. Principally damages of the brain, the brain vessels and the meninges also result from the direction of the impact on the head. We found an adopted Spatz Scheme (Innsbruck modification) valuable to document the direction of impact. This scheme is simple to use and might be applied already at the accident site.
In this lecture biomechanical aspects of typical impact patterns will be presented. Concise evaluation of this data allows the development of an individual neurorehabilitation treatment plan.

**3.2**
**Neurorehabilitation after TBI**

***F. Gerstenbrand'***, *W Struhal*[2];
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Different issues have to be classified in neuroscience, the acute neurology with diagnosis and treatment, the neurorehabilitation with the principle aim for re-socialisation and the neurological care after the end of treatment state with the aim of amelioration of quality of life. Generally Neurorehabilitation has do be differentiated in actual neurorehabilitation (TBI, stroke etc.), temporal neurorehabilitation (Parkinson's Disease, MS etc.) and palliative neurorehabilitation (malign brain tumor, ALS etc.).The demands of modern treatment in TBI are the exact neurological diagnosis in the initial phase (mild to severest forms), documentation of the impact to the skull (Spatz- Innsbruck Scale). The acute treatment of severe and severest forms of TBI should be organized in a neurological ICU. Early rehabilitation has to be started immediately in all forms of TBI followed if necessary by a consecutive phase.
Every patient needs an individual neurorehabilitation program, which has to be executed in a special neurorehabilitation center, organized as a therapeutic community.
In the neurorehabilitation the task-specific repetitive concept is the basis as the neurophysiological treatment. For the restoration in motoric deficits the different methods can be performed (Bobath, Janda, Vojta), a combination with special medicaments is obligate. Deficits of the higher brain functions (aphasia, alexia etc.) and of the highest brain functions (frontal lobe symptoms, temporo basal syndrome) needs a special programme. A specific neurorehabilitation has to be established in patients with a traumatic apallic syndrome, if the rehabilitation is organized in a special center 25 % of them can be socially reintegrated. In apallic patients no prognosis is possible within the first 6 weeks, no decision about ongoing of active treatment programme in the first 6 months can be accepted.
Any discussion about a preterm ending of neurorehabilitation is not acceptable, from a neurological point of view and the ethical demands.

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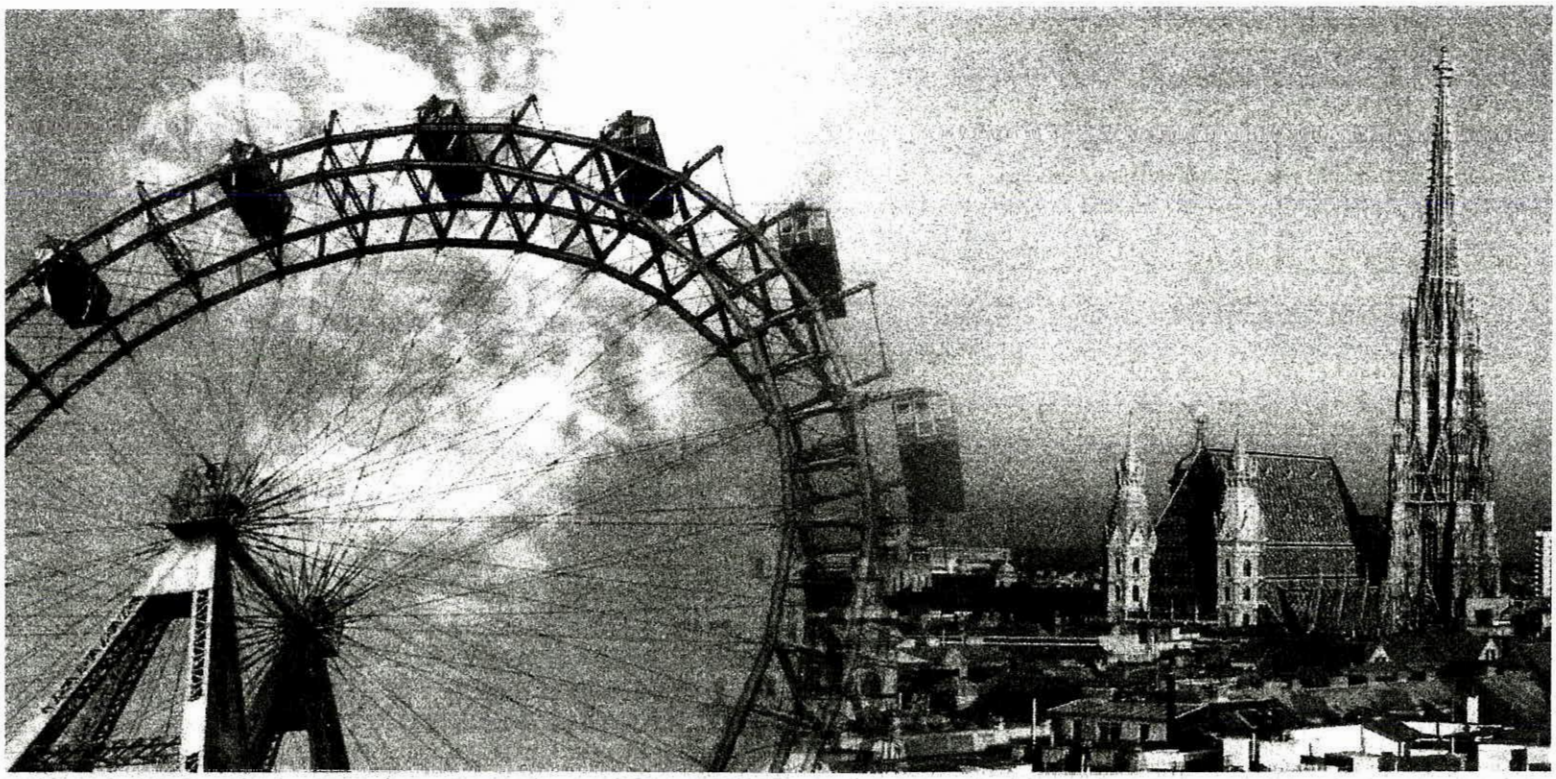

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# *ABSTRACT BOOK*

**www.tbi-challenge.eu**

*Karl Landsteiner Institute for Neurorehabilitation and Space Neurology*

# Neurorehabilitaion after TBI

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1st TBI-Challenge.eu 2011
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## Different Issues In Neurosciences

Clinical neurology – lesions in CNS & PNS

- Acute neurology, diagnosis and treatment
- Neuro-rehabilitation: ➔ the principle aim for re-socialization
- Neurological care in „End-of-treatment"-state, amelioration of quality of life

Basis: Research in neuro-sciences, evidence- and experience-based medicine

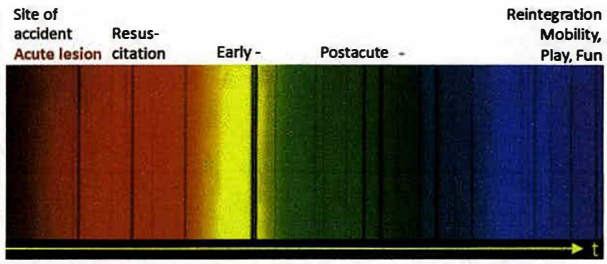
## Classification of Neurorehabilitation WHO-Statement

F. Gerstenbrand, 1968

- Actual neurorehabilitation (stroke, traumatic brain injury, etc.)
- Temporary neurorehabilitation (Parkinson Disease, MS, etc.)
- Palliative neurorehabilitation (malignant brain tumor, ALS, etc.)

## Spectrum of Neurorehabilitation (v. Wild 1993)

Patient's individual course in CNS – PNS lesions (WHO – ICF)

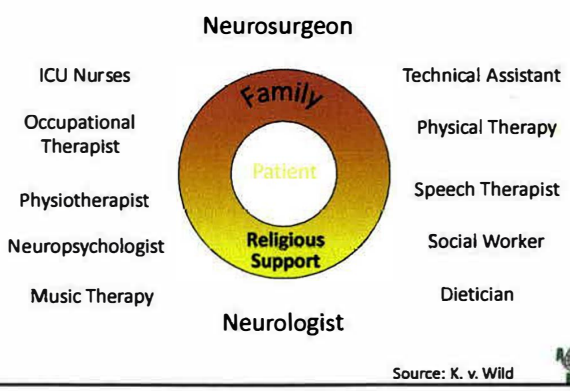



Continuous fluctuation of rehabilitation in analogy to the solar spectrum

Hospital care | First aid | OR | ICU | Ward | Hospital | Out-Patient | Nursing-home

Neurorehabilitation requires a multidisciplinary team approach aiming at the victim's social reintegration

## The Interdisciplinary Team




Source: K. v. Wild

## Neurorehabilitation

**is defined as the**

- ***development of a person to the fullest***
  - ***physical,***
  - ***psychological,***
  - ***social,***
  - ***vocational,***
  - ***avocational and***
  - ***educational potential***

Source: J.A.DeLisa, G.M.Martin, D.M.Currie: Rehabilitation Medicine: Past, Present, and future. In: Rehabilitation Medicine: Principles and Practice. Lippincott Company, Philadelphia, 1993

## Neurorehabilitation

- ***Needs to be consistent with his or her***
  - ***physiological or anatomical impairment and***
  - ***environmental limitations.***
- **It should be comprehensive and include**
  - **prevention,**
  - **early recognition and**
  - **outpatient, inpatient and extended care programs.**

Source: J.A.DeLisa, G.M.Martin, D.M.Currie: Rehabilitation Medicine: Past, Present, and future. In: Rehabilitation Medicine: Principles and Practice. Lippincott Company, Philadelphia, 1993

## Statistics

- **Traumatic injuries accounted for 16% of adult burden of disease in the world in 2002.**
- **Increase in the burden of traffic accidents, especially in the developing countries of sub-Saharan Africa, Southern Asia and South-East Asia, particularly affecting males.**

## Rehabilitation Concepts

- *"neurophysiological" treatment*
- *task-specific repetitive concepts* of motor learning

## Rehabilitation Concepts I

- ***"neurophysiological" treatment*** *concepts*
  - **Restoration** of a most **physiological movement pattern.**
  - **inhibit an increased muscle tone** (spasticity) by gently mobilizing the paretic limbs and opposing synergistic movements,
  - **repeat in short form the statomotor development** of a child as prerequisite for the final goal of a most natural walking habit.
  - Accordingly, tone-inhibiting manoeuvres and motor tasks while lying, sitting or standing dominate therapy sessions of patients, who desperately wish to walk.

## "Neurophysiological" treatment concepts Bobath - Concept

- **Principles:**
  - **Sensomotor recovery**
    - Promotion of disturbed perception by regular appropriate stimuli
  - **Inhibition of pathologic posture and movement pattern**
    - Inhibitory positioning
    - Tonus reducing activities (stretching, manual mobilisation of muscles)
  - **Facilitation of physiologic movement pattern:**
    - Normalizing the **posture tone of trunk,** deduced **top down exercises** of paretic extremity
    - Avoidance of cocontractions and associated reactions **countering pathologic movement patterns**
    - **Implement the contra-lateral extremity** to promote physiologic movement patterns
    - promotion of movement by **proprioceptive and exteroceptive facilitation** in terms of repetitive phasic stretching or stroking the skin

Bobath B (1978) Adult hemiplegia: Evaluation and Treatment. London: Heinemann Medical Books.

## "Neurophysiological" Treatment Concepts Proprioceptive Neuromuscular Facilitation (PNF) (Kabat 1950)

- Improvement of muscular function by **temporal and spatial summation of different stimuli**
  - **Exteroceptive** (tactile, visual, vestibular, verbal)
  - **Proprioceptive** (stretch, traction and approximation, resistance)
- Techniques:
  - **Hold Relax**
  - **Agonist Contract**
  - **Hold-Relax with Agonist Contract**
  - **Rhythmic Initiation**
  - **Slow Reversal**
  - **Rhythmic Stabilization**

Voss D, Ionta MK, Meyers BJ (1985). Proprioceptive Neuromuscular Facilitation. New York: Harper & Row

## "Neurophysiological" Treatment Concepts

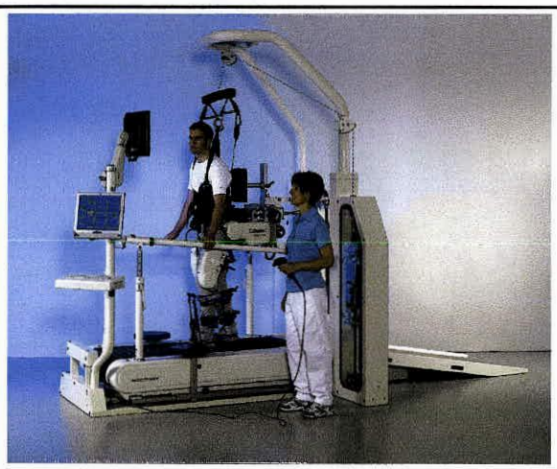
- Sensomotor facilitation (Janda)
- Reflexlocomotion (Vojta)
- Other techniques:
  - Brunkow – Concept (Brunkow)
  - Hippotherapy
  - Klein-Vogelbach – Concept („Funktionelle Bewegungslehre")

## Rehabilitation Concepts II

- ***task-specific repetitive concepts*** **of motor learning**
  a)
  - Locomotor therapy by treadmill training with partial body weight support
  - harness to substitute for deficient equilibrium reflexes,
  - part of his body weight was relieved to compensate for the paresis of the impaired lower limb, and the
  - motor-driven treadmill enforced locomotion.
  - Wheelchair-bound patients up to 1000 steps during a 30 min session as compared to 50 to 100 at maximum during a conventional therapy session.

## Rehabilitation Concepts II

- ***task-specific repetitive concepts*** **of motor learning**
  b)
  - two therapists assist the patients' gait, sitting alongside to place the paretic limb, to ensure an initial contact with the heel, to prevent a knee hyperextensor thrust and to control a symmetric step length. Standing behind the patient, a second therapist shifts the weight according to stance/swing phase, promote hip extension and trunk erection.
  - The concept of locomotor therapy
    - massive gait practice to activate spinal and supraspinal pattern generators
    - efficient cardiovascular training of the deconditioned and often multimorbide patients.



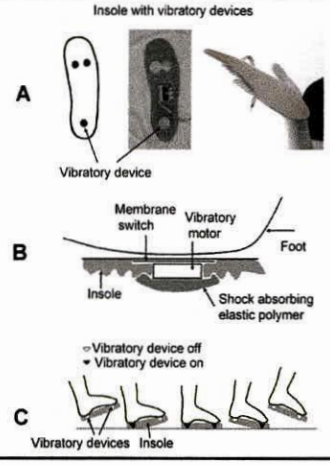
## System after Mauritz, Berlin

## Shrinking General Conditions

- **Comorbidity**
- **Fatigue**

## Task Specific Approach Paradigm for Motor Rehabilitation

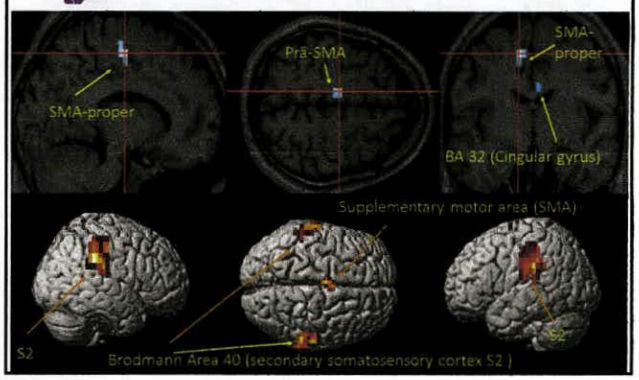
- train as many different daily life walking situations as possible during gait rehabilitation
- Haptic Walker
  - programmable footplates to train arbitrary gait trajectories and daily life walking situations.



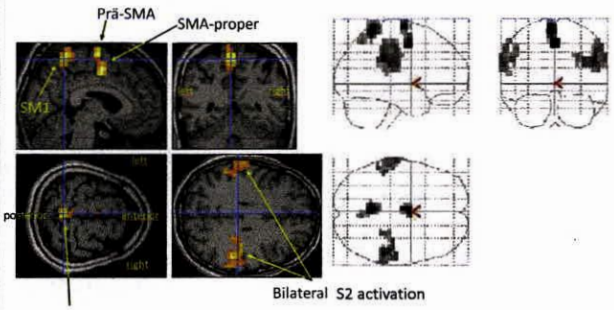

Scheme Of A Foot Sole Stimulation

Standing position, walking

## Vibration of the sole of the foot



## Vibration of the sole of the foot: brain activation within SMA/bilateral Area 40/ contralateral SM1




SM1 (primary sensorimotor cortex contralateral to the vibrated right foot)

## Results Of Vibration

- **Vibratory stimulation of the sole of the foot revealed robust contralateral activation within the primary sensorimotor cortex (SM1), bilateral activation within the secondary somatosensory cortex (S2, Brodmann Area 40), bilateral within the supplementary motor area (SMA, BA 6) and ipsilateral within the cingulate gyrus (BA 32).**

## Different Devices as Spin-off Effect of Space Neurology

- Prevention tools for space missions:
  - treadmill
  - weight trainer
  - trousers with electrostimulators, etc.
- Tools used in neurorehabilitation
  - Pressure shoe – Austrian model
  - Pressure shoe – Russian model
  - Korvit System – Foot loading imitator
  - Regent – treatment suit
  - Penguin System
  - ADELI System

## Prevention Methods During Space Flights


**Same methods used in neuro-rehabilitation:**
neurological disturbances (spasticity, cerebellar disturbances, Parkinson's Disease, polyneuropathy, early dementia state)
Geriatrics
wellness training

Source: Manned Mission to Mars, Russian Academy of Cosmonautics, 2006

## New Neuro-Rehabilitation Methods - 1

Pressure shoe
Austrian model

Used in:

long-lasting coma states (intensive care units), Prevention of bedrest syndrome

Apallic syndrome
Locked-in syndrome

Severe stroke defects

Severe states after traumatic brain injury

Planned: Dementia, Geriatric institutions

## New Neurorehabilitation Methods - 2

Mechanical Stimulator, „Artificial Foot"

Russian model

Used in:
Prevention for bedrest syndrome (ICU)
Parkinson's Disease (mild form), spasticity (mild form), cerebellar symptoms, etc.

Source: Manned Mission to Mars, Russian Academy of Cosmonautics, 2006

## New Neurorehabilitation Methods - 3

Korvit - Foot loading imitator

Used in:
Gait disturbances; Parkinson's disease; spasticity, different origin; spinal cord lesions; polyneuropathy

Planned: Dementia, geriatric institutions

## New Neurorehabilitation Methods - 4

**Regent Treatment Suit**

Used in:

Spasticity
Spinal cord lesions

Parkinson's Disease

Polyneuropathy

Stroke, severe defects

Planned In:

Cerebellar ataxia, Dementia, Geriatric institutions

## New Neurorehabilitation Methods - 5

**Penguin Suit**

Used in:

Cerebral palsy

Spastic spinal paralysis

Planned: Parkinson's Disease, Dementia

## New Neurorehabilitation Methods - 6

Souce: ADELI Flyer

**ADELI SYSTEM**

Used in:
Cerebral palsy
Spastic spinal paralysis
Stroke
Vertebral spine decompensation

Planned:
M. Parkinson
Dementia

Souce: ADELI Flyer

## Scuba Diving – A New Neurorehabilitation method – 1

Partial microgravity,
influence to proprioceptive system

- Diminishing in stimulation of the proprioceptive system
- Diminishing of the vestibular system
- Relaxation of vertebral spine system
- Pathophysiological explanation open
  - Reduced stimulation of the proprioceptive system

## Scuba Diving – A New Neurorehabilitation method - 2

Partial microgravity,
influence to proprioceptive system

- Indications:
  - minimal spinal cord lesions (traumatic, MS, etc.)
  - vertebral spine disturbances
    - cervical myelopathy
    - lumbalgia with radicular/pseudo-radicular symptoms

## Scuba Diving – A New Neurorehabilitation method - 3

Partial microgravity
influence to proprioceptive system

- Additional method in neurorehabilitation
  - Mild Parkinson Syndrome
  - Mild spasticity (after stroke, TBI, etc.)
  - Mild form of cerebellar ataxia

## Scuba Diving in Depth 4 - 5 m

Precondition:

Always in pairs with special trained physio-therapist

## Future Outlook in Neurorehabilitation

- Actual neurorehabilitation of all acute conditions of CNS & PNS, continued as long as improvement can be expected, even for years
- Temporary neurorehabilitation is an ethical obligation for patients with chronic conditions
- Palliative neurorehabilitation is a possibility according to clinical course and condition
- Transfer at the end of neurorehabilitation program to long-term nursing home care only according to prognostic values
- Obligation of amelioration of quality of life

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