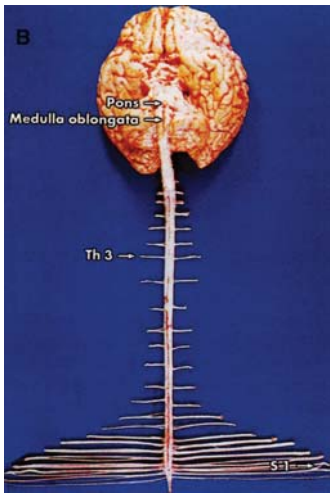
GIGER MD® Therapy

Scientific bases of the GIGER MD®medical device

The human CNS possesses billions of neurons each one of which having connections to an average of approximately 4000 other neurons. New concepts and tools are needed if the inherent complexity of the most complex system of all, the human CNS and its realtion to behavior and thinking, is to be understood and repaired in the case of a lesion. Presently, there is a huge void between the knowledge what a single neuron does (which we know a lot of and what many of them do when they cooperate. The understanding of the principles of organization among large numbers of neurons is of a paramount importance, as this organization lies at the root of the understanding of ourselves, of the world we live in, of how we touch, see, hear, plan, act and think and how we re-learn behaviour and thinking in the case of a CNS lesion. Such fundamental behavioural functions depend on temporally coherent functional units distributed throughout different regions of the CNS, and standard methods have not the potential to elucidate them. For example, responses to sensory stimuli or activities in relation to motor acts are commonly averaged over successive trials in order to improve the signal-to-noise ratio. This averaging procedure destroys any temporal structure in the activation pattern that is not precisely locked to the stimulus or the motor response. Thus, temporal codes were either ignored or remained undiscovered with the commonly applied methods of single unit analysis. In the human neurophysiologic studies simultaneous natural firing patterns of several identified single afferent and efferent neurons were therefore recorded and analyzed, but not averaged. In this way could be discovered the self-organizatinon of premotor spinal oscillators (functional unit of a motoneuron and interneurons) and phase and frequency coordination between the firing of oscillatory and not oscillatory firing motoneurons and afferents.

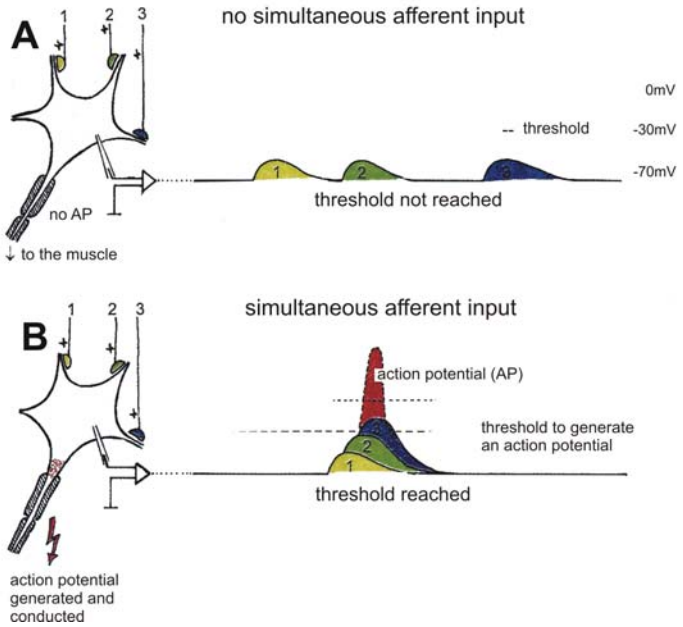


Original Central Nervous System (CNS)

By recording single nerve-fibre action potentials from nerve roots it is possible to analyze simultaneously afferent and efferent impulse patterns and investigate the coupling changes of self-organized premotor spinal oscillators to generate under physiologic conditions and following a CNS lesion, rhythmic and non-rhythmic movements and autonomic functions like continence. These data partly enable the understanding of the integrated functions of the human spinal cord and supraspinal centres; moreover, they allow to substantially improve locomotor and other functions in patients with CNS lesions. A first paradigm shift in the understanding of the functioning of the CNS concerning the self-organization of neuronal networks gives more reorganization possibilities by the so-called neuronal network plasticity. The second paradigm shift, namely that neurogenesis may be induced in the human adult spinal cord and adult brain, opens further possibilities for repair, regeneration and reorganization of the CNS.

In the last 15 years the understanding of the functioning of the CNS has changed, moving away from the rigid reflex and neuronal response chain theories towards the concept of dynamic self-organization of neuronal networks, and this has direct implications for neurorehabilitation because of the increased network plasticity including large scale plasticity. The regulation of neural stem cells and neurogenesis in the intact and damaged adult mammalian and human brain, and probably spinal cord, offers further possibilities with respect to the regeneration and reorganization of the injured human CNS.

Neuron as a coincidence detector



Neuron operating as a coincidence detector. A. Afferent input is not reaching the cell soma at the same time. No action potential (AP) is generated, because the threshold is not reached. B. The action potentials in fibres 1, 2 and 3 are reaching the dendrites approximately at the same time. The postsynaptic potentials add up and the threshold is reached at approximately -30mV, and an action potential is generated at the axon hillock and conducted along the axon. Coordinated afferent input may thus induce or enhance communication between neuronal network parts following CNS lesion.

To improve motor, vegetative and higher mental functions in patients with CNS lesion, it is appropriate to observe neuronal network organization in the human lower sacral range, where motor and vegetative (volitional and automatic) functions are generated. The complexity of neuronal network organization becomes obvious when in addition to somatic also vegetative functions are activated. It is further believed that the vegetative functions are the door to the higher mental functions.
The key strategies on which the discovery of the functional organization of the central nervous system (CNS) under physiologic and pathophysiologic conditions have been based included:

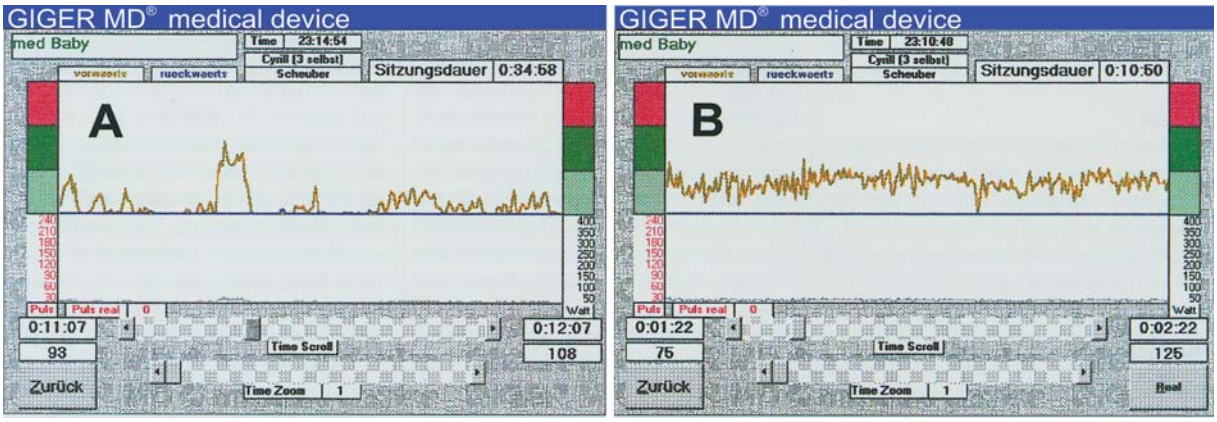
- the measurements of phase and frequency coordination between the firings of α- and γ-motoneurons and secondary muscle spindle afferents in the human spinal cord
- knowledge on CNS reorganization derived upon the improvement of the functions of the lesioned CNS in our patients in the short-term memory and the long-term memory (reorganization)
- the dynamic pattern approach for re-learning rhythmic coordinated behaviour.

The theory of self-organization and pattern formation in nonequilibrium systems is explicitly related to the measurements of the natural firing patterns of sets of identified single neurons in the human spinal premotor network and re-learned coordinated movements following spinal cord and brain lesions. Therapy induced cell proliferation and, maybe, neurogenesis seem to contribute to the host of structural changes during the process of re-learning of the lesioned CNS. So far, coordinated functions like movements could substantially be improved in every of the more than 100 patients with a CNS lesion by applying the **GIGER MD® Therapy**.

Main therapeutic instrument: GIGER MD® medical device

As suggested by the data of the patients on re-learning, the human CNS seems to have a second integrative strategy for learning, re-learning, storing and recalling, which makes an essential contribution to the functional plasticity following a CNS lesion.
A method has been developed for the simultaneous recording with wire electrodes of extracellular action potentials from single human afferent and efferent nerve fibres of undamaged sacral nerve roots.
The theory of reorganizing the lesioned human CNS, based on measurements in humans of self-organization of the human spinal cord neuronal networks, is used to re-learn lost somatic, autonomic functions and higher mental functions in patients with CNS lesions. With the development of the **special therapy device GIGER MD®** to train simultaneously the coordinated

movements of arms, hands and fingers, and legs, feet, and the trunk, an essential further step has been done towards efficient reorganization of lesioned CNS.



Measurement of the coordination dynamic (GIGER MD® system copyright © 1992/2012) after one year (A) and after two years of GIGER MD® Therapy (B). Ordinate = frequency, axis of abscissae = time (from the left to the right = 1 min.). The patient turns independently. The frequency f of the rotation varies more less in B (f ~ 1H). The patient learned to turn more rhythmically; he improved its co-ordination dynamics.

The **GIGER MD® medical device** enables to repair the lesioned CNS by reorganizing (relearning), it became also possible to diagnose instability and deterioration of integrated functions of the CNS in patients with severe lesions or minor deficiencies in the organization of the CNS, such as **spina bifida** and **cerebral palsy**. The essential improvement of higher integrative functions in patients with severe brain lesions by **GIGER MD® Therapy** opens up the possibility to improve higher mental functions in individuals with a severe CNS lesion or a physiologically functioning CNS.

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International contact:
Combo Ltd.
Tugginerweg 3
CH-4503 Solothurn
Switzerland
Phone +41 32 621 97 41
Fax +41 32 621 97 45

www.cp-hotline.com www.spinabifida-online.com www.parkinson-hotline.com