SENSORY STIMULATION THERAPY

By Tobias Kalisch,
Martin Tegenthoff and Hubert R. Dinse

It is well established that training and practicing improves sensorimotor and cognitive functions as well as perceptual and motor abilities. For several years, we have been developing learning protocols that use repetitive sensory stimulation as a measure to induce plastic processes. The basic idea is to utilize the broad knowledge we now have about brain plasticity to design specific stimulation protocols through which it becomes feasible to purposefully change brain organization and thus perception and behavior (Dinse et al., 2005; Godde et al., 2000; Seitz and Dinse, 2007).

Based on this idea, we have introduced new forms of repetitive sensory stimulation protocols that have been shown to induce learning processes that improve tactile and sensorimotor performance in human subjects on a very short time scale of only hours to minutes. The overall gain is comparable to the effects induced by several days or months of training.

Using neuroimaging and electric source localization we demonstrated that the individual behavioral and perceptual gain correlated with cortical map changes (Dinse et al., 2003; Pleger et al., 2001; Pleger et al., 2003). Beneficial effects were not limited to healthy controls, but even stronger learning effects could be found in subpopulations characterized by advanced baseline abilities (Ragert et al., 2004). In order to test the hypothesis that coactivation is mediated by mechanisms requiring NMDA-receptor activation, we used memantine, a selective NMDA receptor blocker, which eliminated coactivation-induced changes both psychophysically and cortically. On the other hand, application of single doses of amphetamine doubled the effectiveness of coactivation (Dinse et al., 2003). Recent studies to explore the dependence of coactivation-induced improvement from attention and conscious awareness revealed that effects were independent from attentional focus (unpublished data).

Coactivation allows systematic exploration of timing requirements for the induction of perceptual and cortical changes. One important line of research therefore is devoted to the development and optimization of new stimulation protocols that are even more effective (Kalisch et al., 2007; Ragert et al., 2008).

Our current view is that coactivation drives synaptic plasticity processes in the cortical areas representing the stimulated sites (Seitz and Dinse, 2007). The observed expansion of the cortical maps can be regarded as a recruitment of processing resources. In an attempt to unify these observations, we used computational mean field approaches which revealed that perceptual impairment depends on changes of amplitude and width of lateral interaction processes (Dinse et al., 2008).

A particular advantage of coactivation is its passive nature, which does not require active participation or attention of the subjects. Therefore, coactivation can be applied in parallel to other occupations and therefore might be substantially easier to implement and has a higher chance of being accepted as intervention. We tested possible therapeutic effects of coactivation in elderly subjects and in patients suffering from stroke. We found that coactivation improved a wide range of sensorimotor abilities in elderly subjects (Dinse et al., 2006; Kalisch et al., 2008). Similar results were obtained from a group of subacute and chronic stroke patients after several weeks of daily application of coactivation (Dinse et al., 2008; Smith et al., 2009).

Combined, the effectiveness of coactivation in improving tactile and sensorimotor performance makes coactivation-based principles prime candidates for interventions, serving to augment cognitive abilities in both healthy and impaired populations.

REFERENCES

Dinse, H. R., Bohland, J., Kalisch, T., Kraemer, M., Freund, E., Beeser, E., Hömberg, V., and Stephan, K. M. (2008). *Europ. J. Neurol.* 15, s3, 449.

Dinse, H. R., Kalisch, T., Ragert, P., Pleger, B., Schwenkreis, P., and Tegenthoff, M. (2005). *Transaction Appl. Perc.* 2, 71-88.

Dinse, H. R., Kleibel, N., Kalisch, T., Ragert, P., Wilimzig, C., and Tegenthoff, M. (2006). *Ann. Neurol.* 60, 88-94.

Dinse, H. R., Ragert, P., Pleger, B., Schwenkreis, P., and Tegenthoff, M. (2003). *Science* 301, 91-94.

Dinse, H. R., Wilimzig, C., and Kalisch, T. (2008). Grunwald ed (Birkhäuser), pp. 165-182.

Godde, B., Stauffenberg, B., Spengler, F., and Dinse, H. R. (2000). *J. Neurosci.* 20, 1597-1604.

Kalisch, T., Tegenthoff, M., and Dinse, H. R. (2007). *BMC Neurosci.* 8, 58.

Kalisch, T., Tegenthoff, M., and Dinse, H. R. (2008). *Clin. Interv. Aging* early online.

Pleger, B., Dinse, H. R., Ragert, P., Schwenkreis, P., Malin, J. P., and Tegenthoff, M. (2001). *Proc. Natl. Acad. Sci. USA* 98, 12255-12260.

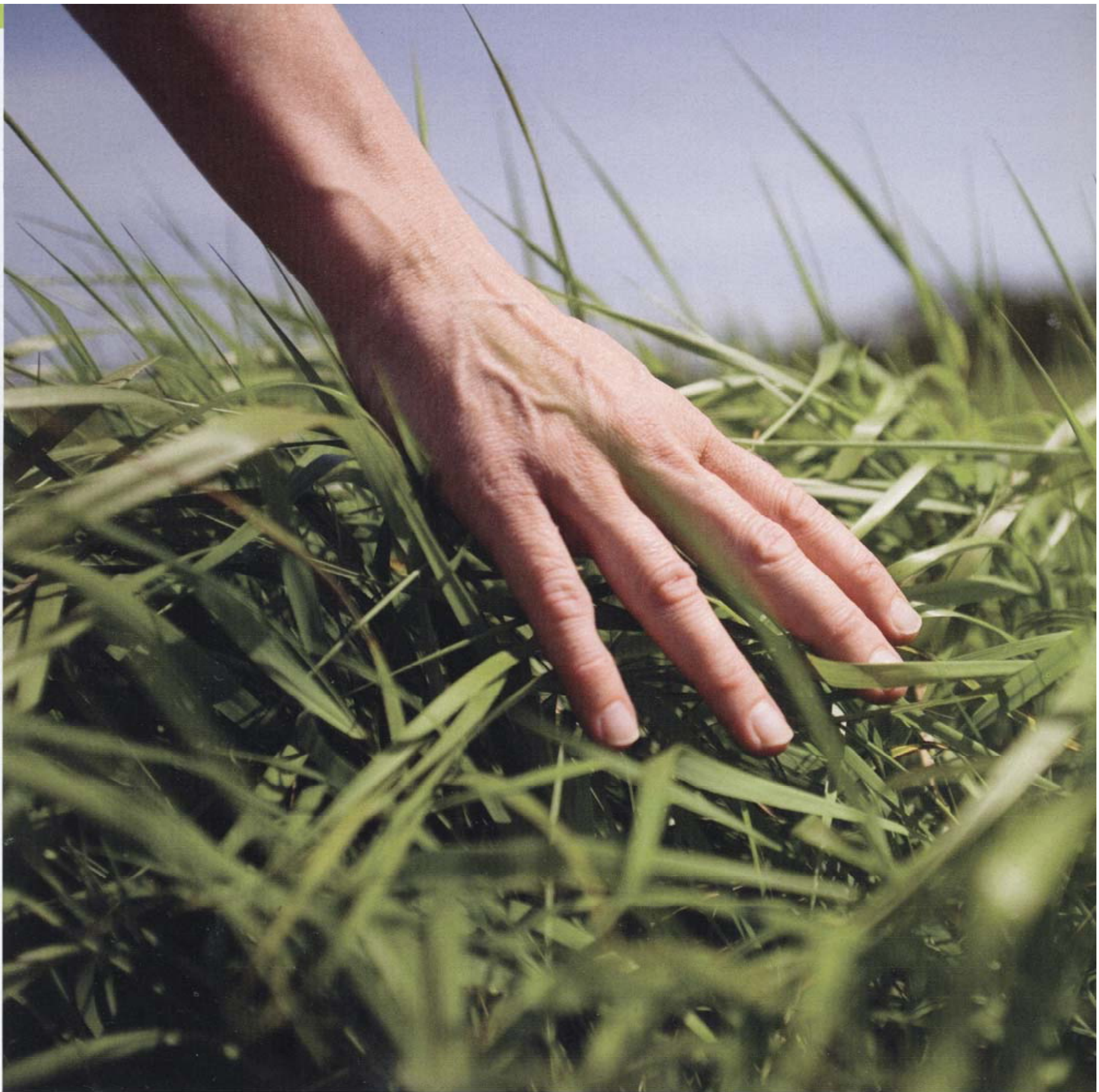
Pleger, B., Foerster, A. F., Ragert, P., Dinse, H. R., Schwenkreis, P., Nicolas, V., and Tegenthoff, M. (2003). *Neuron* 40, 643-653.

Ragert, P., Kalisch, T., Bliem, B., Franzkowiak, S., and Dinse, H. R. (2008). *BMC Neurosci.* 9, 9.

Ragert, P., Schmid, A., Altenmueller, E., and Dinse, H. R. (2004). *Europ. J. Neurosci.* 19, 473-478.

Seitz, A., and Dinse, H. R. (2007). *Curr. Op. Neurobiol.* 17, 1-6.

Smith, P. S., Dinse, H. R., Kalisch, T., Johnson, M., and Walker Batson, D. (2009). *Arch. Phys. Med. Rehab.* (in press).



Tobias Kalisch studied biology at the Ruhr-University of Bochum, Germany, where he received his Master degree in 2003 and his Ph.D. in 2006. In 2004, he was awarded a Ph.D. scholarship from the Schering-Stiftung, Germany, for the investigation of age-related changes of the human sensorimotor performance and possible rehabilitative interventions. He had been working at the Neural Plasticity Lab at the Institute for Neuroinformatics, Ruhr-University, since 2002. In 2008, he started as a Post-Doctoral Fellow at the Department of Neurology of the Bergmannsheil Hospital in Bochum, Germany.
tobias.kalisch@ruhr-uni-bochum.de

Martin Tegenthoff studied medicine and physics at the Westfälische Wilhelms-University in Münster, Germany, where he obtained his M.D. He became a medical specialist in Neurology and Psychiatry, and is a Senior Physician and Professor since 2006 at the Department for Neurological Traumatology and Neurorehabilitation at the Berufsgenossenschaftlichen University Hospital Bergmannsheil in Bochum, Germany. His scientific research interests are neurophysiological foundations and mechanisms of the sensorimotor and visual system, as well as basic research in pain and neuroimaging.
martin.tegenthoff@ruhr-uni-bochum.de

Hubert R. Dinse studied biology, chemistry and physics at the Philips-University in Marburg and the Johannes Gutenberg-University in Mainz, Germany, where he obtained his Ph.D. Since 1990, he has been serving as Associate Professor at the Institute for Neuroinformatics at Ruhr-University, Bochum, Germany, where he heads the Neural Plasticity Lab. He is the Vice Chair of the Department of Theoretical Biology, since 2006. His main research areas include tactile and haptic perception, learning and plasticity, aging, development of new learning protocols, rehabilitation and therapy.
hubert.dinse@ruhr-uni-bochum.de