ON THE VIRTUES OF VIRTUAL LESIONS

Review of *Virtual Lesions: Examining Cortical Function with Reversible Deactivation*. Edited by Stephen G. Lomber and Ralf A.W. Galuske. ISBN 0-19-850893-X, Oxford University Press. 357 pages, Price U.K. £ 34.95; U.S. $ 89.50.

One of the main goals of systems neuroscience is to gain a better understanding of the relation between brain and behavior. Over the years, a variety of ingenious techniques have been used in an attempt to meet this goal. One approach is to take advantage of the fact that humans get (and animals can be given) permanent lesions that damage certain parts of the brain. By assessing the deficits that result from the damage one can infer that the affected area normally contributed to the function that is now degraded or lost entirely. Although this approach has been and continues to be used with great success, one of its disadvantages is that the resulting functional deficits may reflect the extent to which the remaining intact parts of the brain can compensate for the damaged structures. The fact that such compensation can occur is made abundantly clear by the remarkable degree of functional recovery that is quite often observed in patients who suffer from a stroke affecting the motor cortex. Such recovery is thought to occur as a result of other motor areas of the brain taking over the function of the damaged cortex. Put another way, structural plasticity leads to functional elasticity. Thus, with permanent lesions one may unwittingly be assessing the adaptability of the rest of the brain as opposed to the specific function of the affected site.

To avoid this potential confusion in interpretation researchers have, in the last quarter century, developed reversible deactivation techniques which temporarily ‘knock out’ structures of interest. The logic being that the short-term nature of these ‘virtual lesions’ does not allow the rest of the brain enough time to compensate for the deactivation, and, thus, one is able to examine the functional consequences of this manipulation in relative isolation. In the new book *Virtual Lesions: Examining cortical function with reversible deactivation*, research in which this technique has been brought to bear on a variety of questions within sensory and motor neuroscience is discussed by leading scientists in the area. The research described in each of the chapters uses a variety of different deactivation techniques and one of the strengths of the book is the often detailed descriptions of how the virtual lesions were carried out, what affects they had both behaviorally and neurophysiologically, and the resulting pros and cons of a specific method. In this respect, the editors should be commended for letting the authors give the readers the whole story rather than the abbreviated version often found in the original journal articles.

The different deactivation techniques vary in terms of their spatial and temporal resolution. Focal iontophoresis of neurotransmitter antagonists allows deactivation of small groups of neurons within a cortical site. This technique has been used to great effect, for example, in advancing the understanding of orientation and direction tuning columns within the primary visual cortex. In addition, several of the authors in this volume have used this technique to deactivate relevant brain regions for extended periods of time during development. In this way, it becomes possible to examine the necessity of activity in particular brain circuits at critical periods of times.

A second category of reversible deactivation technique involves cooling the neural tissue with a cryoprobe or injecting neurotransmitter antagonists through a cannula. The amount of cortical tissue that is deactivated with these techniques is typically much larger than that observed when iontophoresis is used. This may seem like a bad thing at first glance but researchers have used it to their advantage to deactivate large portions of cortical tissue. With appropriate adjustments in the rate and magnitude of cooling/injection it becomes possible to more or less knock out a specific cortical area and then address how it may contribute to a specific type of task. Thus, the questions one can address with this form of deactivation are on the systems as opposed to the local circuitry level.

Although each of these reversible deactivation techniques have allowed new insights into the role of specific brain circuits or areas in particular behaviors, they have one major shortcoming: their effects are not on the same time scale as neuronal activity. Thus, although they can help to answer the question of *if* an area of the brain is necessary for normal task performance they can not be used to ask *when* during the task the area makes its most relevant contribution. This is overcome with the third main deactivation technique discussed in the book: transcranial magnetic stimulation or TMS. With TMS one is able to very briefly disrupt cortical processing while a subject is performing a task of interest. Because the effects of the stimulation are brief, one can deliver the perturbation at several different points in time relative to different trial epochs (i.e., at the instructional cue, target appearance, response onset, etc.). By quantifying performance deficits as a function of stimulation time it becomes possible to address the question of when a specific brain region is necessary for normal task performance. Thus, TMS provides an additional piece of information concerning the relation between brain and behavior.

This is an excellent book for those who are interested in how reversible deactivation techniques can be applied to questions concerning sensory and motor neurophysiology. Unfortunately, the research described in the book tends to be limited to these two aspects of central nervous system function. This may partially reflect the fact that deactivation techniques are best suited to these systems. However, there are number of instances in which reversible deactivation techniques have been applied to questions related to cognition, language, and learning. For example, TMS applied over the left inferior frontal area has recently been shown to selectively affect syntactic decisions (Sakai et al., 2002). In addition, although most of the research described in the book examines cortical deactivation, there is also some data presented from subcortical deactivation. Again, there are numerous additional instances of this approach that would have added to the breadth of this book. For example, temporary deactivation in different portions of the cerebellum during eye-blink conditioning has greatly increased our understanding of the neural mechanisms underlying this simple form of learning (Thompson and Kim, 1996). However, other than these shortcomings, this book is an excellent resource for anyone interested in the use of reversible deactivation to address systems neuroscience questions. I virtually could not put it down.

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References

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