The Cognitive Electrophysiology of Mind and Brain makes explicit that scalp electrical recordings have joined other methods as a means of understanding the connections between brain and mind. Only seven years ago, I wrote a foreword to a new volume, Electrophysiology of Mind (Rugg and Coles, 1995). That book summarized the use of electrical recording as a chronometric tool to describe the time course of mental operations, but no explicit effort was made to relate these findings to other approaches to neuroimaging. In that foreword, I suggested that the future of scalp electrical recording lay in firm connections to hemodynamic imaging methods such as PET and fMRI. Acceptance of the full import of these connections is still inhibited. However, in my view and those of most of the authors of this volume, it is time to face the consequences of localization of generators in neural tissue, by making efforts to use electrical recording methods to probe the time course of anatomical areas recruited in performing cognitive functions.

The effort to understand the origins and significance of the brain’s electrical and magnetic signals is detailed in Chapter 2. The methods for linking them to underlying generators in the brain are described in several of the chapters; these efforts are active areas of research (e.g., Dale et al., 2000). A number of algorithms are already available as commercial packages, and new ideas, like those described in Chapters 5 and 11, are being developed. Within the visual system, there has been very detailed validation linking these generators to retinotopic maps found in several visual areas. For complex skills, the evidence is less complete, but because tasks like visual imagery, reading, and number processing have yielded widely separated generators, it has proven possible to provide detailed analysis of their time course from scalp electrical recordings (Abdullaev and Posner, 2000; Dehaene, 1996; Posner and McCandliss, 1999; Raij, 1999).

Even if researchers reading this book are convinced that electrical recordings can play a role in probing the organization of neural networks involved in cognition, it does not mean that all controversies are settled. In fact, the controversy may be more severe, because if scalp electrodes are to be integrated with lesion studies, cellular recording, and hemodynamic imaging as a means of probing both mind and brain, we will have to be serious about reasoning from the combination of these methods.
Chapter 3 provides a very useful summary of many findings that indicate different cognitive function (e.g., working memory and attention) often recruit the same brain area. The authors are surely correct that cognitive psychology textbook chapter titles are not an appropriate guide to brain localization. However, before we conclude that different operations activate the same brain area, we need to be more clear about what makes a difference in mental operations. For example, theories of working memory assume the involvement of attentional networks, so it would be surprising not to find attention areas active in working memory tasks, but it is rather easy to design an attention task that does not involve working memory. We also need to be more explicit about what the same brain area means (i.e., the extent of overlap needed to assume identity). Finally we need to know when in the task a particular area is active. Both perception and imagery tasks may activate prestriate visual areas, but the latter may do so only after activation of higher association areas.

The use of electrical recordings is important for tracing the time course of brain activity and for indexing communication between neural areas. This book shows how such recordings can be useful in analyzing generators of the electrical signals in real time as is done in chapters on language (Chapter 6), memory (Chapter 7), executive function (Chapter 8), and attention (Chapters 10, 11, and 12). These chapters also discuss event related potentials, while steady state electrical potentials are discussed in Chapters 4 and 11, and some concerns with the use of oscillations and correlations within particular frequency bands as a means of probing communication between neural areas are discussed in Chapters 5 and 8.

The editors have also made a significant attempt to give new readers the background necessary to understand the material contained in the volume. Chapter 1 deals with general theoretical issues and Chapter 2 reviews how electrical and magnetic signals arise from neural tissue and get conducted to the sensors from which they are recorded. Appendixes A—F provide a primer of brain recording techniques as applied to normal persons and those suffering from neurological disorders.

The visual system, including visual attention (Chapters 4, 5, 8, 10, 11, and 12), has been the best area for the close integration of hemodynamic, lesion, and EEG work. In my view, the results have been very impressive. A few years ago, it was puzzling that different areas of the parietal and occipital lobes were active during attention tasks. However, by use of event related fMRI methods it now seems clear that the superior parietal lobe is most related to orienting (e.g., voluntary shifts of attention), while the temporal parietal junction is most important for processing novel or unexpected events. Lesions of the TOJ and surrounding areas are also closely related to the neurological phenomena of extinction and neglect. The occipital sites, which are related to the processing of target identity, while not a part of the attention systems per se, can, like most brain areas, be amplified during an attentive act. Detailed analysis of the orienting network tends to bring into harmony the study of lesions, hemodynamic imaging, and electrical recording.

Cognitive neuroscience involves functional anatomy, circuitry, plasticity, and pathology. All these topics are well represented within the volume. Although most chapters deal with circuitry (i.e., time course of processing), chapters on memory, vision, development, and self-regulation provide substantial backgrounds in how the brain changes with experience and maturation. Human brain development is becoming an increasingly important field of research (see Chapter 9 and Posner, Rothbart, Farah and Bruer, 2001). For example, new methods are now available for examining the development of white matter pathways in the human brain by use of diffusion tensor MRI. This could
open up the prospect of using measures of the development of coherence between distant electrode sites as a means of probing the earliest functional use of particular white matter pathways. In addition to Chapter 9, which deals with some forms of atypical development, a whole section of the volume is devoted to applications to neurological patients (Chapter 13) and clinical application of mismatch negativity.

This volume sets research with the brain’s electrical and magnetic signals squarely within the large and growing tool kit of methods that have opened up the black box and made the human brain accessible to detailed investigation. What is the next step? A goal must be to move beyond the box score data summaries found in Chapter 3, to reveal the principles through which brain areas are assigned to functions and get assembled into circuits. We are starting to have the requisite clues to do this for visual attention and some high level skills like reading and numeracy. It will be a great challenge, but reading this book and absorbing its many lessons should give the researchers of the next generation a good start.

References


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