Berg, P., & Scherg, M. (1994). A multiple source approach to the correction of eye artifacts. *Electroencephalography & Clinical Neurophysiology*, *90*(3), 229–241.

Gratton, G., Coles, M. G. H., & Donchin, E. (1983). A new method for off-line removal of ocular artifact. *Electroencephalography and Clinical Neurophysiology*, *55*, 468–484.

Hillyard, S. A., & Galambos, R. (1970). Eye movement artifact in the CNV. *Electroencephalography and Clinical Neurophysiology*, *28*, 173–182.

Jung, T. P., Makeig, S., Humphries, C., Lee, T. W., McKeown, M. J., Iragui, V., & Sejnowski, T. J. (2000). Removing electroencephalographic artifacts by blind source separation. *Psychophysiology*, *37*, 163–178.

Jung, T. P., Makeig, S., Westerfield, M., Townsend, J., Courchesne, E., & Sejnowski, T. J. (2000). Removal of eye activity artifacts from visual event-related potentials in normal and clinical subjects. *Clinical Neurophysiology*, *111*, 1745–1758.

Lins, O. G., Picton, T. W., Berg, P., & Scherg, M. (1993). Ocular artifacts in EEG and event-related potentials I: Scalp topography. *Brain Topography*, *6*, 51–63.

Lins, O. G., Picton, T. W., Berg, P., & Scherg, M. (1993). Ocular artifacts in recording EEGs and event-related potentials. II: Source dipoles and source components. *Brain Topography*, *6*, 65–78.

Picton, T. W., Linden, R. D., Hamel, G., & Maru, J. T. (1983). Aspects of averaging. *Seminars in Hearing*, *4*, 327–341.

Verleger, R., Gasser, T., & Moecks, J. (1982). Correction of EOG artifacts in event-related potentials of the EEG: Aspects of reliability and validity. *Psychophysiology*, *19*(4), 472–480.

Woldorff, M. (1988). Adjacent response overlap during the ERP averaging process and a technique (Adjar) for its estimation and removal. *Psychophysiology*, *25*, 490.

5 Filtering

This chapter discusses the application of filters to the EEG during data acquisition and to ERP waveforms before and after the averaging process. It is absolutely necessary to use filters during data acquisition, and it is very useful to apply filters offline as well, but filtering can severely distort ERPs in ways that ERP researchers frequently do not appreciate. For example, filters may change the onset and duration of an ERP component, may make monophasic waveforms appear multiphasic, may induce artificial oscillations, and may interfere with the localization of generator sources. This chapter will explain how these distortions arise and how they can be prevented. To avoid complex mathematics, I will simplify the treatment of filtering somewhat in this chapter, but there are several books on filtering that the mathematically inclined reader may wish to read (e.g., Glaser & Ruchkin, 1976). Note also that the term *filter* can refer to any of a large number of data manipulations, but this chapter will be limited to discussing the class of filters that ERP researchers typically use to attenuate specific ranges of frequencies, which are known as *finite impulse response filters*.

ERP waveforms are generally conceptualized and plotted as *time-domain* waveforms, with time on the X axis and amplitude on the Y axis. In contrast, filters are typically described in the *frequency-domain*, with frequency on the X axis and amplitude or power on the Y axis.[1] Because ERP researchers are typically more interested in temporal information rather than frequency information and because temporal information may be seriously distorted by filtering, it is important to understand filtering as a time-domain operation as well as a frequency-domain operation.[2] This chapter therefore describes how filters operate in both the time and