TABLE 2.1 *(continued)*

TECHNIQUE	MAIN ADVANTAGES	MAIN DISADVANTAGES
Event-related potentials (ERPs)	Very high temporal resolution	Coarse or problematic spatial resolution
	Noninvasive	Difficult to disentangle multicomponent activity
	Inexpensive, fast, and easy recording procedures	Activity may be associated with but not essential for the task
Magnetoencephalography (MEG)	Very high temporal resolution	Picks up mainly only sulcal activity
	Better localization than ERPs	Limited spatial localization
	Noninvasive	Much more expensive than ERPs
		Recordings very susceptible to interfering noise
		Activity may be associated with but not essential for task
Positron emission tomography (PET)	Good spatial resolution (three dimensional)	No temporal resolution
	Identifies network of regions associated with task	Cannot do event-related designs (block design only)
		Need cyclotron
		Need to inject radioactive molecules
		Indirect measurement of neuronal activity
		Activated areas may be associated with but not essential for the task
Functional magnetic resonance imaging (fMRI)	Very good spatial resolution	Spatial resolution still has limits (e.g., draining veins)
	Temporal resolution much better than PET	Temporal resolution still very low (typically a few seconds)
	Can do event-related designs	Indirect measurement of neuronal activity
	Identifies network of regions associated with task	Activated areas may be associated with but not essential for the task
	Noninvasive	
Optical imaging (hemodynamic)	High spatial resolution	Almost exclusively limited to animals
	Temporal resolution a bit better than fMRI	Temporal resolution still fairly low (hundreds of milliseconds)
	Can do event-related designs	Indirect measurement of neuronal activity
	Can image all across a cortical area simultaneously	Activated areas may be associated with but not essential for the task
Optical imaging (EROS)	Moderate spatial resolution	Low signal-to-noise ratio; may require multiple sessions or be able to image only limited brain regions
	Good temporal resolution	Mainly sensitive to the more superficial cortical regions
	Noninvasive	Activated areas may be associated with but not essential for the task

The different limitations of each of these methods, as well as their complementary scales, have led to a growing effort to combine approaches in the same or closely allied studies. For example, hemodynamic measures of brain activity like fMRI are very good at showing which areas of the brain are activated

TABLE 2.1 Summary of the Major Imaging Techniques Used in Cognitive Neuroscience

TECHNIQUE	MAIN ADVANTAGES	MAIN DISADVANTAGES
Naturally occurring lesions	Can strongly implicate a region as being essential for a task	Still generally need double dissociation to strongly confirm selectivity of area
	Occur naturally	Not specific to functional areas; variable in distribution and extent
		Do not identify a network
		No temporal resolution
		Relatively few available subjects; subjects often from heterogeneous groups
		Effects of recovery unknown or complex
Directed lesions	Can strongly implicate a region as being essential for a task	Can generally be done only in animals; ethical concerns
	Can be much more selective than naturally occurring lesions	Very limited temporal resolution
	Can be timed (e.g., before or after training)	
Intracranial stimulation	Can provide rather specific neural perturbation	Mostly limited to animals and rare clinical circumstances
		In humans, clinical concerns, limited locations that can be stimulated
Transcranial magnetic stimulation (TMS)	Advantages of lesions, but transient and noninvasive (or at least nonsurgical)	Mostly can do only superficial cortex
	With single shot, can get some temporal resolution	Not very focused; stimulates other areas nearby and above the target area
		Even for some superficial brain regions, is too uncomfortable
		Some safety issues, particularly for repetitive TMS (rTMS)
Single-unit recordings	High spatial and temporal resolution	Picks up only some neurons (typically larger ones)
	Very specific (single neurons)	Very invasive; almost completely limited to animals
		Typically from only one brain area, thus does not identify a network or network interactions
Electroencephalography (EEG)	Good temporal resolution	Coarse or problematic spatial resolution
	Good for state effects (e.g., arousal, sleep stages)	Not very specific for information processing or cognitive function
	Noninvasive	
	Inexpensive, fast, and easy recording procedures	

Multimethodological approaches

All of the individual methods described here provide a way of linking cognitive processes to underlying brain processes. Each has advantages and disadvantages. The spatial and temporal ranges of these approaches were depicted in Figure 1.6. The most important advantages and disadvantages of each method are described in Table 2.1.