A biology major at college, Emily has always been interested in the brain. One day, while walking back from class, she saw a flyer advertising a “Functional Neuroimaging Study” that used MRI to study the brain. The flyer stated that the study would last about two hours, she would be compensated for her time, and she would be able to see pictures of her own brain. The study sounded intriguing, and she called the laboratory to get more information.

Before the Experiment
When she called the laboratory, Emily was nervous. She didn’t know very much about MRI, and she wanted to learn more about the technique. The researcher on the phone told her about what would happen in the study. The primary goal of this research, he said, was to investigate which parts of the brain were responsible for working memory, the ability to actively maintain information over time. During the experiment, she would lie in the MRI scanner and watch a series of shapes presented one after another. Whenever she saw a particular shape, she would press a button on a joystick. The MRI scanner would then measure the changes in her brain that occurred each time she pressed the button. The experiment sounded interesting to Emily, and she told the researcher that she wanted to participate.

The researcher then told Emily that he would need to ask her a set of questions to determine whether she was eligible to participate in the study. He asked her whether she had any metal in her body, like a pacemaker or aneurysm clip; whether she had any nonremovable body piercing; and whether she was claustrophobic. Emily did not have any medical condition that prevented her from participating, so she passed this screening test. The researcher then scheduled Emily for an fMRI session the following week.

Setting Up the Subject
On the day of the fMRI session, Emily was only slightly apprehensive. She was prepared for the scanning when she arrived at the hospital MRI center, having left her wallet, jewelry, and book bag in her dorm room. She had also worn clothing without any metal, as she had been instructed. She was greeted at the entrance by a graduate student, who escorted her to the MR console room. There she met an MR technologist, whose job it was to run the MR scanner. The console room was large and contained several computers.

Brain Imaging and Analysis Center
Part 1: For all individuals entering the scanner room

<table>
<thead>
<tr>
<th>Name</th>
<th>Last name</th>
<th>First name</th>
<th>MLI</th>
<th>Birth Date</th>
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<tbody>
<tr>
<td>Address</td>
<td>Zip Code</td>
<td>Phone (H)</td>
<td>City</td>
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1. Have you had any previous MRI studies or been in a MR scanner? □ No □ Yes
   If yes, please list (most recent first):

   □ Body part □ Date □ Facility Location

2. Have you ever worked with metal (grinding, fabricating, etc.) or ever had an injury to the eye involving a metallic object (e.g., metallic device, shavings, foreign body)?  □ No □ Yes
   If yes, please describe:

3. Have you ever had surgery or other invasive medical procedure? □ No □ Yes

Some of the following items may be hazardous to your safety or may interfere with the MRI examination. Do you have any of the following:

- Yes □ No □ Cardiac pacemaker or defibrillator
- Yes □ No □ Intravascular pump
- Yes □ No □ Cochlear implant
- Yes □ No □ Hearing aid
- Yes □ No □ Any implanted metal (e.g., clamps, valves, clips, shunts, catheters)
- Yes □ No □ Body piercing(s)
- Yes □ No □ Tattoos or permanent makeup (e.g., eyeliner, lips)
- Yes □ No □ Artificial limb or prosthesis
- Yes □ No □ Bone/joint pins, screw, nail, wire, plate
- Yes □ No □ Wire sutures or surgical staples
- Yes □ No □ Any implant held in place by a magnet (e.g., dental)
- Yes □ No □ Transdermal delivery system (Nitro)
- Yes □ No □ Tissue Expanders (plastic surgery)
- Yes □ No □ Colored contact lenses
- Yes □ No □ Any metal fragments (e.g., shrapnel)

Other, please explain:

Before you enter the scanner room you must remove all metallic objects.

- Yes □ No □ All contents of pockets, including back pockets
- Yes □ No □ Wrist watch, any bracelets
- Yes □ No □ Hair pins, clips, weaves, fasteners
- Yes □ No □ Pins or badges on shirt
- Yes □ No □ Belt with metal (e.g., buckle)
- Yes □ No □ Shoes that contain any metal (e.g., steel-tipped)
- Yes □ No □ Hearing aids or other electronic devices
- Yes □ No □ Pagers, cell phones, PDAs
- Yes □ No □ Dentures or removable retainers
- Yes □ No □ Necklaces, chains

Note: You are required to wear earplugs or earphones during the MRI examination.

Signature of Person Completing Form Date

Figure 2.9 A sample screening form used for functional MRI studies. This form would be filled out by a prospective subject before a research study. The experimenter would then examine the form to make sure that the subject has no condition (e.g., ferrous metal in the body) that would preclude participation in the study.
BOX 2.1 (continued)

Through a window, she saw the MR scanner, which was behind a locked door. The graduate student gave her several pieces of paperwork to fill out, including a consent form that described the study and a screening form that asked her questions about medical conditions, and medications (Figure 2.9). The graduate student explained that Emily was participating in this experiment as a research volunteer, so she could quit the study at any time for any reason. Emily was also told that the experimenters would talk with her throughout the experiment to make sure that she was not having any problems. After Emily read and signed the consent and screening forms, she was ready to begin the study.

The technologist looked over Emily’s forms to verify that she could participate and then asked her whether she had anything in her pockets or in her hair. At first, Emily thought that this was a strange question, but the technologist quickly explained that they wanted to make sure that people did not bring any metal with them into the scanner room. When Emily checked, she realized that she had left her keys in her pocket, and she placed them on a table. Once Emily made sure that she had no metal on her, the technologist unlocked the scanner room and escorted her inside. Emily sat down on the table at the front of the scanner, and the technologist handed her some earplugs. As Emily put the earplugs in, the technologist explained that the scanner would be loud and that the earplugs would reduce the noise to a comfortable level. Emily then lay down on the table. The technologist handed her a joystick and placed a pair of goggles over her eyes. The goggles had tiny computer screens inside! The technologist also gave her a squeeze ball that was connected to an alarm in the console room. If Emily became uncomfortable or needed help immediately, she could squeeze the ball to summon the technologist.

Although she couldn’t see the scanner room anymore, due to the goggles, she could feel a pillow being wrapped around the sides of her head. The technologist told her that this was a vacuum pack that would support her head and help keep her from moving during the experiment; after a few seconds, Emily heard a hissing sound and the pillow hardened to form a solid cushion. A plastic cylinder called a volume coil then slid around her head (Figure 2.10). The technologist then told her that she was about to go into the scanner, and Emily found herself slowly moving back into the bore.

Structural and Functional Scanning

The technologist returned to the control room and then asked Emily over an intercom how she was feeling. Emily said that she was doing fine; her nervousness had worn off, and she was pretty comfortable in the scanner. The technologist then told her that she would hear some knocking noises while the scanner took pictures, called structural images, of her brain anatomy. The first knocking noise startled her, because she had expected the scanner to be quiet, like an X-ray machine. After the initial shock wore off, she ignored the noise and just thought about the scanner session. She looked forward to seeing pictures of her brain and wondered whether it was normal. The structural images took about 10 minutes, and then the technologist told her that it was time for the experiment to begin. The graduate student had previously explained that she was supposed to watch for circles to be presented on the screen. Whenever she saw a circle,

Figure 2.10 Setting up a subject in the scanner. The experimental subject is being positioned in the scanner before a research study. She is holding a joystick in her right hand that will be used for recording behavioral responses. The technologist standing next to the scanner is moving the table so that the subject’s head is in a particular position. Once the subject is positioned properly, the technologist will move the volume radiofrequency coil forward so that it fits around the subject’s head and then send her into the bore of the scanner.
she was supposed to press a button on the joystick. Emily told the technologist that she was ready to begin.

The experiment was broken into a series of 6-minute runs. In each run, Emily saw a large number of different shapes. Each time she saw a circle she pressed the button. Once or twice, she was trying so hard to look for the circles that she pressed the button for another shape. Overall, though, she made very few mistakes. Between the runs, the technologist talked to her to see how she was doing. After about 10 runs, the experiment was finished and the technologist came into the room to bring her out of the scanner. Emily was a little tired from concentrating for an hour, but she had still enjoyed the experiment and she wanted to see the pictures of her brain.

After the Experiment
Emily sat down in a chair next to the MR console. The graduate student explained that they were investigating changes in the brain associated with how people remember and use rules for behavior. Each time a shape was presented, her brain had to identify the correct shape and to remember what rule to follow when that shape was presented. Emily asked which areas of her brain were active during the experiment, and the graduate student told her that her data would have to be analyzed by computer programs back in the laboratory before they could answer that. They could, however, show her the structural images they had collected. The graduate student loaded the structural images onto the scanner console (Figure 2.11). They had collected two sets of structural images: a set of sagittal images that showed a side view of her brain and a set of axial images that showed a bottom-up view of her brain. After Emily was finished asking questions, she picked up her keys from the table, and the graduate student walked her back to the entrance to the scanner. Emily said she would be happy to participate in another session in the future, and then she went back to her dorm to rest.

Figure 2.11 Reviewing the anatomical MR images after the experiment. The graduate student who ran the experiment explains the nature and purpose of the experiment. She shows the subject pictures of her brain and discusses the goals of the research.

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Thought Question

Why do you think that belief in the biological effects of magnetic fields has persisted, in the absence of strong evidence in support of such effects?

The study of the health effects of magnetic fields long predates MRI. In the 1920s, the prevalence of large industrial magnets in the factories of the day prompted the physiologists Drinker and Thompson to study the effects of magnetic fields upon both cells and animals. No health effects were found. Yet by the 1980s and 1990s, the possible health consequences of magnetic fields reemerged into public awareness, as people worried about exposure to power lines, cellular telephones, and MRI scanners. While a full dis-