Question 1: How is it possible for a split-brain person to speak intelligibly if the left hemisphere controls speech? Isn't this inconsistent with the fact that the left hemisphere must direct motor cortex in both hemispheres to coordinate movements of the mouth?

Answer: Some midline features are represented in both sides of the brain, such as the fovea, which is represented in both right and left hemispheres. Motor control of the mouth and larynx may be similarly represented on both sides of the brain. In addition, the motor system works according to the population code rather than a strict one-to-one correspondence between neural activity and neural output. This may "loosen" the topographic relationships between motor cortex and motor output. Finally, the two hemispheres can communicate via the anterior commisure in split-brain individuals because this subcortical fiber tract remains intact when the corpus callosum is severed.

Question 2: What can you conclude about the normal function of Broca's area from the observation that there are usually some comprehension deficits in Broca's aphasia? Must Broca's area itself be directly involved in comprehension?

Answer: Functional localization is an appealing and important concept that helps us understand how the nervous system processes sensory information and commands motor output. But it is important not to lose sight of the interconnectedness of various brain structures. The predominant function of Broca's area is language expression, and this function is diminished when Broca's area is lesioned. But the entire circuitry of language processing must also be disrupted in the absence of this structure, affecting the functioning of the circuit as a whole, including Wernicke's area, which appears to mediate language comprehension. In addition, Broca's area does not have easily discernable boundaries, and strokes rarely involve discrete regions of cortex. Such lesions may involve other brain structures beyond Broca's area. Finally, it is quite possible that Broca's area participates in language comprehension even though its main function is language expression.

Question 3: Pigeons can be trained to press one button when they want food and other buttons when they see particular visual stimuli. This means the bird can "name" things it sees. How would you determine whether or not the pigeon is using a new language—"button-ese"?

Answer: Human language is creative—new word combinations and sentences are constantly being made, and the combinations have clear meaning according to the meaning of the individual words plus the rules for arranging them. Animals use symbols to identify known objects, but creative use of symbols appears to be limited. A good way to determine whether an animal is capable of language is to see whether the animal can use the symbols it has learned in novel combinations, *i.e.*, combinations that have not been taught, to signify novel stimuli.

Question 4: What does the Wernicke-Geschwind language-processing model explain? What data are inconsistent with this model?

Answer: The Wernicke-Geschwind language processing model offers simple explanations for key elements of Broca's and Wernicke's aphasias. A lesion in Broca's area seriously interferes with speech production because the proper output signals for speech execution can no longer be sent to motor cortex. On the other hand, comprehension is relatively intact because Wernicke's area is undisturbed. A lesion in Wernicke's area produces serious comprehension problems because this is the site where sounds are transformed into words.

The ability to speak is usually unaffected because Broca's area is able to drive the muscles required for speech. The following data is inconsistent with the Wernicke-Geschwind model:

i) Words do not have to be transformed into a pseudoauditory response in Wernicke's area. Visual information can reach Broca's area from visual cortex without making a stop at the angular gyrus.

ii) The severity of Broca's and Wernicke's aphasias depends on how much cortex is damaged beyond the limits of Broca's and Wernicke's areas. In addition, aphasia is influenced by damage to subcortical structures, such as the thalamus and caudate nucleus, which are not in the model. When parts of cortex are surgically removed, the resulting language deficits are usually milder than the deficits resulting from stroke, which affects both cortical and subcortical structures.

iii) There is significant recovery of language function after a stroke. Other cortical areas apparently compensate for what is lost.

iv) Most aphasias involve both comprehension and speech deficits.

Question 5: In what ways is the left hemisphere usually language dominant? What does the right hemisphere contribute?

Answer: Hemispheric dominance for language is best illustrated by the responses of people with a severed corpus callosum when visual input is restricted to only one hemisphere. Numbers, words, and pictures visually presented in the right visual field (and thus the left hemisphere of the brain) can be repeated or described with no difficulty because the left hemisphere is usually dominant for language. In addition, objects manipulated by the right hand (but out of view of both eyes) can be described. However, such simple verbal descriptions of sensory inputs are not possible for the right hemisphere. If an image is shown only in the left visual field or an object is felt only by the left hand (and thus the right hemisphere), a split-brain subject is unable to describe it. This absence of response by the right hemisphere is a consequence and demonstration of the left hemisphere being language dominant. The right hemisphere has language comprehension and can read and understand numbers, letters, and short words as long as the required response is nonverbal.

Question 6: What evidence is there that Broca's area is not simply a premotor area for speech?

Answer: Several lines of evidence indicate that Broca's area is not simply a premotor area for speech.

i) The difference in the aphasic's ability to use content words and function words suggests that Broca's area and nearby cortex may be particularly involved in making grammatical sentences out of words.

ii) Wernicke suggested that the area damaged in Broca's aphasia contains memories for the fine series of motor commands required for articulating word sounds, and this theory is upheld by some people.

iii) Comprehension is good with Broca's aphasia but comprehension deficits can be demonstrated by tricky questions.

iv) In addition, patients sometimes have considerable anomia, suggesting that they have problems "finding" words as well as making the appropriate sounds.