Question 1: What differences are there between the conscious states of a person with neglect syndrome and a split-brain individual who can only describe things in the right visual field?

Answer: In neglect syndrome, a person appears to ignore objects, people, and sometimes his own body to one side of the midline. In severe cases, the patient behaves as if half the universe no longer exists (*e.g.*, draws half a clock face, eats food from only one side of his plate). Most cases occur from lesions in the posterior parietal cortex in the right hemisphere. In split-brain individuals, both the hemispheres work like independent brains without acknowledging the contribution of the other side. Split-brain individuals can only describe things in the right visual field because the left hemisphere is dominant for language. They do not neglect the left visual field; they are unable to identify works and objects verbally because the right hemisphere has no verbal output. For example, embarrassing images shown to the left visual field can evoke blushing and laughter even if the subject says he sees nothing, indicating that the image has been perceived.

Question 2: In what ways is unilateral spatial neglect different from blindness in half of the visual field?

Answer: In the case of unilateral spatial neglect, the patient behaves as if half the universe no longer exists. He may shave only one side of his face, brush the teeth on only one side of his mouth, dress only one side of his body, and eat food from only one side of his plate. It is known to be more common following the right hemispheric damage. The patient acts as if there has been shrinkage in the left half, leading to a problem in space perception. However, he can see objects in the neglected half, but simply ignores them. In blindness, a person is unable to perceive anything in the blind visual field, yet he or she still attends to objects in

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the blind half of the visual field by using other senses. In blindness, a person has no difficulties viewing objects in the intact half of the visual field and has no problems of space perception. Finally, people with neglect syndrome often recover, at least partially, whereas blindness caused by a loss of visual cortex is permanent.

Question 3: How would you use fMRI or PET imaging to look for brain areas involved in directing selective attention in humans?

Answer: The fMRI technique has been used to visualize how brain activity changes when the location of the visual sector being attended to changes. (Subjects always kept their gaze fixed at the center of the bull's-eye stimulus.) Depending on what part of the visual field is being attended to, the pattern of brain activity shifts retinotopically. This indicates that selective changes in brain activity are typically associated with spatial shifts in attention in a pattern that follows the retinotopic organization of visual cortex. The technique of PET imaging was used when humans performed a same-different discrimination task—the images were identical, but subjects attended to different features, such as color, direction of movement, and so on. Brain activity shifted to different visual areas depending on what features were attended to, *e.g.*, there was more activity in V4 when the subjects were attending to color. These effects of attention to different features are roughly consistent with the tuning properties of neurons in extrastriate visual areas. Similar experiments could be conducted for the other sensory systems. It is interesting to examine subcortical structures such as the pulvinar.

Question 4: What neural mechanism(s) could be responsible for the receptive field changes observed in area V4 in response to shifts in attention?

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Answer: Robert Desimone and his colleagues at the National Institute of Mental Health have revealed specific effects of attention on the response properties of neurons in visual cortical area V4. Two sets of stimuli are presented within a neuron's receptive field, but one set is effective in producing action potentials and the other is ineffective. When the subject attends to the effective stimuli the neuron fires action potentials. When the subject attends to the ineffective stimuli the neuron fires much less, although the effective stimuli are still present on the other side of the receptive field. It's as though selective attention enabled the neuron to ignore the effective stimuli in the unattended side of the receptive field. Perhaps inhibitory interneurons help prevent the cell from firing when attending to ineffective stimuli. Such neurons need to be governed by attentional mechanisms. Alternatively, attentional mechanisms may be able to shrink the area of the receptive field to which the neuron is sensitive by enhancing sensitivity in the attended side rather than dampening sensitivity in the unattended side.

Question 5: How are shifts in attention and eye movements related?

Answer: There appears to be a close association between eye movements and attention. Recent experiments suggest that the brain circuitry responsible for directing the eyes to objects of interest might also play a critical role in guiding attention. Two sets of experiments are relevant here. First, Robert Wurtz and colleagues showed that the response of neurons in the posterior parietal cortex of awake, behaving monkeys is enhanced *before* the animal makes a saccade to a specific target within the neuron's receptive field (the receptive fields are quite large here). This increased neuronal activity prior to the saccade is thought to be a consequence of shifting attention as preparation for shifting eye position. Second, Moore and

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colleagues examined the frontal eye fields (FEF) in awake, behaving monkeys. Neurons in the FEF have motor fields—small areas in the visual field—and when a sufficient electrical current is passed into the FEF, the eyes rapidly make a saccade to the motor field of the stimulated neuron. The researchers also showed that passing a small amount of current through neurons in FEF lowered the threshold needed for that neuron to detect dimming in the target stimulus, *i.e.*, the researchers artificially enhanced the responsiveness of the neuron by stimulating the FEF neuron, simulating what happens when the animal attends to the stimulus.

Question 6: How might feedback from the frontal eye fields modulate the responses of neurons in visual cortex?

Answer: FEF neurons make direct connections with numerous areas known to be influenced by attention, including areas V2, V3, V4, MT, and parietal cortex. Moore and colleagues also showed that stimulating neurons in FEF can enhance the sensitivity of neurons in distant visual areas such as V4. The feedback from FEF neurons apparently primes the visual cortical neurons in other parts of cortex so they are more likely to fire an action potential when an effective stimulus is presented. The nature of this input is not known, but FEF neurons may depolarize the neurons in distant cortical areas sufficiently to change their threshold for firing an action potential.

Question 7: How would a system for guiding attention to features differ from a system directing attention to different locations?

Answer: A system for guiding attention to features will require the observers to pay attention to either a single feature or all features and base their judgment on changes in features

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regardless of locations. This will involve individual visual cortical areas specialized for different stimulus features, such as V4, which is specialized for color, area IT, and other visual cortical areas in the temporal lobe. A system for guiding attention to location will always require the observers to make use of their retinotopic maps, which are represented in several visual cortical areas in the occipital lobe.

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