PURPOSE

To investigate the processing of motion boundaries in the human occipital lobe using functional magnetic resonance imaging (fMRI).

QUESTIONS

- How is MT involved in processing of motion boundaries?
- What other areas respond to motion boundaries?

BACKGROUND

EXPERIMENT

Stimulus

Paradigm

- Time-averaged motion statistics identical throughout experiment.
- Difference between conditions: presence of motion boundaries.
- Parametric variations:
  - Density of motion boundaries
  - Speed of surface motion signal

Visualizing Functional Activity on the Flattened Brain

- Input: 3-d reconstruction of subjects brain
- Process: Segment and "inflate" the cortical surface, cut along calcarine fissure and flatten.
- Output: Flattened map of occipital lobe.

Canonical Area Mapping

- Areas V1, V2, V3, ventral V4 and V3A were mapped using phase-encoded retinotopic stimulation.
- Areas MT and V3A were identified by their selectivity for low-contrast visual motion.

RESULTS

ACTIVATED	FAILED TO ACTIVATE
V1	**MT**
V2	...
V3	...
V3A	...

Subject Variability

Stimulus: .82 cycle/degree concentric rings vs. uniform motion

- Area variability: V1 not always entirely activated (subjects EW, AL)
- Retinotopic variability: activity restricted with respect to eccentricity in the visual field (subject EW)

EXPERIMENTAL VARIATIONS

Variation 1

Density of motion boundaries

Results

For all three types of stimuli used (rings, pinwheel, checkerboard):

- Motion segmentation at different densities leads to selective activation with the same anatomical pattern.
- Activation of areas are scale-dependent:
  - V1 - fine-scale
  - V2, V3, ventral V4 - intermediate-scale.
  - V3A - coarse-scale
- MT does not selectively respond to motion boundaries.
- No other area responds selectively to motion boundaries.

Variation 2

Speed of surface motion signal

Observation: Boundaries less salient at extremely high (32 deg/sec) and extremely low (.8 deg/sec) speeds.

Results

For all three types of stimuli used (rings, pinwheel, checker-board):

- V1 responds less to extremely high and extremely low speeds, consistent with perceptual salience of motion boundaries.
- Results from other retinotopic areas are qualitatively similar.

CONCLUSION

- MT does not differentiate between segmented and uniform motion at any scale.
- Retinotopic visual areas (V1, V2, V3, V3A, ventral V4) respond selectively to motion boundaries.
- Responsiveness of retinotopic visual areas is dependent on the scale of motion boundaries.

Inferences

Given that:

- MT is needed to segment motions (Regan et al 1992, Marcar and Cowey 1992, Siegel and Andersen 1988)
- Retinotopic areas (V1, V2, V3A, V3, and V4) respond to motion-defined form (this study, Lamme et al 1994, Marcar and Cowey 1992)

Feedback from MT onto the retinotopic areas is required for the perception of motion-defined form.

ARVO 1996

Motion Boundaries in the Human Visual System

John Reppas, Harvard
Sourabh Niyogi, MIT
Roger Tootell, Harvard

MOTION BOUNDARY

RINGS

Cues:
Relative motion

MOTION BOUNDARY

PINWHEELS

Cues:
Relative motion
Kinetic occlusion

MOTION BOUNDARY

CHECKERBOARD

Cues:
Relative motion
Kinetic occlusion