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Abstract:

Introduction: Accurate perception of the speed of motion is important for visually guided actions, but its neural basis is much less understood than the perception of the direction of motion. The current study aims to identify areas in the human brain that represent speed information in a manner that is compatible not only with veridical but also illusory speed perception.
It has previously been shown that single neurons in the macaque middle temporal area have lower preferred speeds at low contrast than at high contrast. This interaction between speed and contrast led to the rejection of the labeled line model of speed perception in macaque MT (Krekelberg et al. 2006). Our specific goal in the current study was to determine whether human MT showed a similar interaction between speed and contrast, and whether there are other areas in which either a contrast-invariant, or an illusion-compatible representation of speed can be found.

Methods. Participants viewed random dot patterns that traveled along a circular pathway. In a trial, the pattern could move at one of five speeds (2-32 deg/s) and have either low or high contrast. BOLD responses measured by a 3T Allegra scanner were compared across ten conditions and to a baseline in which the dots were stationary. Inspired by the known properties of macaque MT neurons, we constructed a model with two subpopulations of neurons per voxel with log-Gaussian speed tuning. The free parameters in the model were the relative abundance of high (32 deg/s) versus low (4 deg/s) speed preferring neurons, and the reduction in preferred speed with contrast. We fit this model to the BOLD response in each of the voxels in V1 and in MT.

Results: In V1 we typically found a monotonic increase in BOLD response with speed for the high contrast stimulus. The low contrast patterns often led to low BOLD responses . Consistent with its predominantly magnocellular input, MT voxels' response to low contrast moving patterns was more robust. The model fits revealed that while V1 voxels were dominated by fast speed preferring neurons, many MT voxels also had significant contributions from slow-speed preferring neurons. Similar to the reported finding in macaque MT, preferred speeds were lower at low contrast in human MT. This effect was even more pronounced in V1 of human subjects. Very few voxels in any visual area showed a contrast invariant representation of speed and no consistency in such a representation could be found across subjects.

Conclusion:
Speed and contrast interact in human MT as they do in macaque MT. This interaction leads us to reject the standard model of speed perception that is based on labeled line

readout of area MT. Our imaging data not only confirm the rejection of the model for humans, they also suggest that there are no other visual areas that fit the bill of a labeled line model for speed perception. We conclude that an alternative to the labeled line model needs to be found for the perception of speed.

References

Krekelberg B., van Wezel R.J.A., Albright T.D. (2006), 'Interactions between Speed and Contrast Tuning in the Middle Temporal Area: Implications for the Neural Code for Speed', *The Journal of Neuroscience*, vol. 26, no. 35, pp. 8988-8998

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