Encoding the Time Course of Saccades in Macaque Lateral Intraparietal Area (LIP)

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Primates frequently make saccadic eye movement to direct their fovea on objects of interest in order to receive acute visual information. However, saccades can cause serious problems to vision due to sliding and displacing the retinal image of still objects. To retain visual stability, the pre- and postsaccadic visual information need to be updated / integrated at the right moment, making the time course of saccades crucial. Current belief associates the source of real-time saccadic signal with the oculomotor plants, such as superior colliculus2-4 and cerebellum5. However, the real-time saccadic signal has not been identified in the cortical regions. Here we show that the activity of neurons in macaque lateral intraparietal area (LIP) which was previously reported to be involved in spatial perception6,7, saccadic planning8-10, and other cognitive processing11-17, to be highly correlated with the time of saccade onset or offset. First, some presaccadic response neurons decayed activity either around the time of saccade onset (saccade-on-decay) or offset (saccade-off-decay). However, the time difference between saccade-off-decay and saccade-on-decay activity was not precisely correlated with the real saccadic duration, but rather correlated with a fixed interval (predicting the time course of saccades). Furthermore, the activity decay was more precisely correlated with saccade offset than saccade onset, indicating that saccade offset was more crucial for the integration of pre- and postsaccadic visual information. Second, another group of neurons vigorously and briefly discharged immediately following the time of saccade onset or offset. The peak activity plateau of these neurons precisely corresponded with the real saccadic duration (monitoring the time course of saccades). Taken together, these two saccade timing related signals (predicting and monitoring) in LIP might play important roles in facilitating and calibrating the visual integration across saccades for accurate spatial perception and action navigation.

References:

[1] Wurtz, R. H. Neuronal mechanisms of visual stability. Vision Res 48, 2070-2089 (2008).

[2] Sparks, D. L. Functional properties of neurons in the monkey superior colliculus: coupling of neuronal activity and saccade onset. Brain Res 156, 1-16 (1978).

[3] Waitzman, D. M., Ma, T. P., Optican, L. M. & Wurtz, R. H. Superior colliculus neurons mediate the dynamic characteristics of saccades. J Neurophysiol 66, 1716-1737 (1991).

[4] Dorris, M. C., Pare, M. & Munoz, D. P. Neuronal activity in monkey superior colliculus related to the initiation of saccadic eye movements. J Neurosci 17, 8566-8579 (1997).

[5] Thier, P., Dicke, P. W., Haas, R. & Barash, S. Encoding of movement time by populations of cerebellar Purkinje cells. Nature 405, 72-76 (2000).

[6] Colby, C. L. & Goldberg, M. E. Space and attention in parietal cortex. Annual review of neuroscience 22, 319-349 (1999).

[7] Duhamel, J. R., Colby, C. L. & Goldberg, M. E. The updating of the representation of visual space in parietal cortex by intended eye movements. Science 255, 90-92 (1992).
[8] Barash, S., Bracewell, R. M., Fogassi, L., Gnadt, J. W. & Andersen, R. A. Saccade-related activity in the lateral intraparietal area. II. Spatial properties. J Neurophysiol 66, 1109-1124 (1991).
[9] Barash, S., Bracewell, R. M., Fogassi, L., Gnadt, J. W. & Andersen, R. A. Saccade-related activity in the lateral intraparietal area. I. Temporal properties; comparison with area 7a. J Neurophysiol 66, 1095-1108 (1991).
[10] Andersen, R. A. & Buneo, C. A. Intentional maps in posterior parietal cortex. Annual review of neuroscience 25, 189-220 (2002).
[11] Kiani, R. & Shadlen, M. N. Representation of confidence associated with a decision by neurons in the parietal cortex. Science 324, 759-764 (2009).
[12] Sugrue, L. P., Corrado, G. S. & Newsome, W. T. Matching behavior and the representation of value in the parietal cortex. Science 304, 1782-1787 (2004).
[13] Glimcher, P. W. The neurobiology of visual-saccadic decision making. Annual review of neuroscience 26, 133-179 (2003).
[14] Maimon, G. & Assad, J. A. A cognitive signal for the proactive timing of action in macaque LIP. Nat Neurosci 9, 948-955 (2006).
[15] Shadlen, M. N. & Newsome, W. T. Neural basis of a perceptual decision in the parietal cortex (area LIP) of the rhesus monkey. J Neurophysiol 86, 1916-1936 (2001).
[16] Freedman, D. J. & Assad, J. A. Experience-dependent representation of visual categories in parietal cortex. Nature 443, 85-88 (2006).
[18] Balan, P. F. & Gottlieb, J. Functional significance of nonspatial information in monkey lateral intraparietal area. J Neurosci 29, 8166-8176 (2009).