The dynamic representation of eye position in primary visual cortex.

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Visual input would be of little use if not accompanied by knowledge of eye position; indeed, it is the combination of these signals that allows the brain to localise and interact with objects meaningfully. Although eye-position signals have been observed throughout visual cortex – including the primary visual area (V1) – little is known about how well such signals represent the eye during fixation and across eye movements. **Methods:** We examined the static and dynamic representation of eye-position in parafoveal V1 of an alert macaque by recording extracellular activity as the animal performed sequences of fixations and saccadic eye movements. To probe population codes for eye position, we recorded from multiple neurons (typically 3-10) simultaneously using a multielectrode array. **Results:** Neurons showed substantial modulations of visually-evoked activity by the position of the eyes in the orbit (i.e. 'gain fields'). We used these tuning functions to decode the eye position from the collected spikes on a trial-by-trial basis, thereby allowing an assessment of the reliability of eye-position representation. We found that the position of the eyes could be predicted to within a few degrees of visual angle during fixation, even using as few as two V1 neurons. Further, the representation of eye position was updated rapidly after the offset of saccades (within 50-100ms). These findings point to a highly reliable and nimble representation of eye position in primary visual cortex. However, because retinal slip had strong effects on evoked activity during the saccade, large errors in eye position

representation were observed during the peri-saccadic interval. **Conclusions:** The representation of eye position in V1 is sufficient to support fluid and accurate visuomotor behaviour.