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D̶͟I̶S̶C̶O̶N̶J̶U̶G̶A̶T̶E̶ ̶A̶D̶A̶P̶T̶A̶T̶I̶O̶N̶ IN RHESUS MONKEYS. ̶A̶.̶ ̶C̶h̶e̶n̶g̶a̶, D. Zee, S. Das, The Johns Hopkins Hospital, Baltimore, MD.

When human beings wear optical devices that call for each eye to rotate by a different amount with every change of gaze, an adaptive mechanism "disconjugately" adjusts innervation so the eyes can be relatively realigned during saccades (Levi, Collewijn, Schor; ARVO 87). We report experiments in monkeys to further characterize this capability. Monkeys wore binocular search coils. A piece of translucent plexiglass, attached to a head holder, was placed in front of each eye to which Fresnel prisms could be adhered. For example, in front of one eye, a 2 diopter base-out prism was positioned to displace images from the temporal field and a 2 diopter base-in prism to displace images from the nasal field. The central field (15 deg) was undisturbed. This optical combination called for divergence (1 deg) in the far right, convergence (1 deg) in the far left and no change centrally.

After habitually wearing the prisms (eg. for 7 days) both static (the phoria) and dynamic (intrasaccadic) ocular alignment changed. These changes persisted during monocular viewing i.e. they became independent of disparity cues. The phoria adapted as expected across the visual field though the change near the prism edge was gradual, not abrupt. Changes in intrasaccadic alignment also reflected the anisotropic effects of the prism combination. For example, during saccades from 0-L15 and 0-R15 there appeared 0.9 deg of convergence and 0.8 deg of divergence, respectively.

In conclusion, monkeys undergo adaptation to optimize binocular ocular motor function. Furthermore, selective displacement of images from various portions of the visual field of one eye relative to the other is a convenient way to explore the versatility and limitations of disconjugate adaptive mechanisms.

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SLOW SACCADES IN ALERT HUMANS. Steve Whittaker, Roger Cummings and Jim Carroll. Pennsylvania College of Optometry; Phila., PA 19141.

In a review of the literature and after some additional experiments, we have found that saccades resulting in foveation of salient targets (V_f-Saccades) are faster than 1) saccades to remembered target positions (R-Saccades) and 2) saccades that intentionally avoid foveation of a target. The non-foveation saccades (V_{nf}-Saccades) are generated in normal subjects by intentionally overshooting, undershooting or looking away from a target. Using an objectively-calibrated search coil eyetracker, we have confirmed the Smit et. al. (1987) findings that the maximum speed of R-Saccades are consistently slower than V_f-Saccades in 4 normally-sighted subjects (2 subjects with adducting and 2 subjects with abducting horizontal saccades to unpredictable target positions). Moreover, we found that the quick phase of "stare" OKN measured during the same session was even slower than R-Saccades.

We have also replicated the V_f-Saccade procedure with 11 patients with long-standing, confirmed macular lesions, where the resultant saccades consistently moved the image to eccentric retinal loci rather than to the fovea. When the data were pooled across subjects, we found that the saccades of low-vision subjects were significantly slower than those of normally-sighted subjects. (Albeit, the distribution of maximum velocity/amplitude functions did overlap.) There appears to be a mechanism operating when saccades foveate salient targets, which influences saccades at the level where the pulse and step components are generated and/or combined.

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STIMULUS VERSUS TASK DETERMINANTS OF SACCADIC VELOCITY. Peter Van Gelder, Sergey Lebedev and Wai Hon Tsui, The Nathan S. Kline Institute for Psychiatric Research and Dept. of Psychiatry, New York University Medical Center, New York, 10016.

Purposive and predictive saccades have been shown to have lower maximum velocities and different cortical origins than do visually elicited saccades. We used a saccadic reaction time paradigm to refine further the notion of a visually elicited saccade. Our target onset condition had four target alternatives, at 4 and 10 deg to either side of a central fixation point, with no time uncertainty. Our target remaining condition used the same targets, except that all four were displayed initially; the subject moved to the target that remained when three of the targets were extinguished. The target onset condition seemed to activate tectal alerting mechanisms, while the target remaining condition was processed by visual analysis mechanisms, as evidenced by (1) much faster reaction times in the onset condition, (2) a distance by task interaction, where the outer targets had longer reaction times for the target remaining condition, but there was no distance effect for the onset condition, (3) a cueing by task interaction, where an amplitude cueing procedure was effective for the target remaining task only. In contrast to these reaction time differences, no saccadic velocity differences between tasks were seen. We conclude that task effects were seen at input and processing stages, but that a common oculomotor stage was employed. This suggests that the presence of a target determines the selection of oculomotor pathways, independent of actual target onset or the complexity of cortical processing.

SPATIAL DISTRIBUTION OF CORTICO-PONTINE FIBERS ORIGINATING IN AREAS CONCERNED WITH VISUAL PURSUIT. James C. Lynch and Regina M. Allen, Departments of Anatomy and Ophthalmology, University of Mississippi Medical Center, Jackson, MS 39216

The inferior parietal lobule (IPL) has traditionally been considered to be the source of neural signals from the cerebral cortex that control pursuit eye movements, acting via projections to the dorsolateral pontine nuclei (DLPN). However, recent studies have demonstrated that the frontal eye fields (FEF) also play an important role in visual pursuit. We have compared the patterns of termination within the pontine nuclei of pathways originating in the frontal and posterior eye fields. Tritiated amino acids were injected into either the anterior bank of the arcuate sulcus (FEF) or one of two functionally distinct subregions of the IPL (areas POa and PGc) in twelve hemispheres of macaque monkeys. Standard autoradiographic techniques were used to localize the transported label. Cortico-pontine fibers from the FEF terminated in the dorsomedial portion of the pontine nuclei (DPN and PPN of Nyby and Jansen, 1951), whereas fibers originating in area POa terminated primarily in a crescent-shaped region of the lateral pontine nuclei (DLPN and LPN). In some cases there was modest overlap between the regions of the FEF and the POa terminal fields, but in other cases the terminal fields did not overlap at all. Fibers from area PGc tended to terminate more medially than fibers from POa and consistently overlapped a portion of the FEF terminal field.

Thus far, physiological studies of the pontine nuclei have indicated that only the lateral part of these nuclei are directly concerned with visual pursuit. The present results therefore suggest that pursuit information from the FEF may influence the brainstem oculomotor system via another, as yet undisclosed, pathway.

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SACCADES FROM NEURAL ACTIVITY Herschel P. ̶G̶o̶l̶d̶s̶t̶e̶i̶n̶, Eye Movement Center for Children, Wills Eye Hospital, Philadelphia, PA.

The net torque applied to the globe by the extraocular muscles during a saccade has a 'pulse-slide-step' (Collins et al 1975) form. Similarly, the spike rate profile found on oculomotor motoneurons encoding saccadic movements has either a 'pulse-slide-step' waveform, for the agonist muscle, or a 'pause-slide-step' waveform, for the antagonist muscle (Goldstein 1983). Models adequately predict the net torque signal from real eye movement (Robinson 1964, Goldstein 1984). The remaining problem was to generate the net torque signal from the spike rate signal recorded on isolated abducens units.

On comparison, calculated net torque for a 20° saccade only grossly resembles the motoneuron spike rate profile: the pulse in neural activity arises far faster than the torque pulse and the amplitude ratio of the neural pulse to the neural step is much greater than the ratio of the corresponding torque components. A distributed, nonlinear model element was devised to solve the problem. The element has three components: 1) a saturation to limit the maximum torque a motor unit can develop; 2) a jitter process that simulates, from a representative spike rate record, the net effect of a pool of motoneurons that do not burst or pause simultaneously at the beginning of a saccade; and 3) a linear muscle component that generates torque from the net motoneuron signal. Simulations, using parameters with physiological values, make synthetic saccades that closely match the trajectory of the real saccades while also predicting physiological net torque. By increasing the jitter variance, slow saccades with significantly longer durations result, suggesting that variability in the synchrony of motor unit activation could explain the normal variability in the saccadic waveform of equal amplitude saccades without necessarily implicating the local-feedback, bang-bang model. Difficulty in creating post-saccadic drift by changing jitter variance suggests that poorly formed neural signals, rather than bad timing of well-formed neural signals, underlie dysmetric saccades of central origin.

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PREDICTION OF SACCADIC AMPLITUDE FROM OBSERVED EYE POSITION THROUGH RECONSTRUCTION OF NEURAL SIGNALS. W. James MacLean, B.A.Sc., Richard C. Frecker M.D., Ph.D., Moshe Eizenman, Ph.D., Visual Sciences Laboratory, Institute of Biomedical Engineering, and Department of Electrical Engineering, University of Toronto, Toronto, Canada. M5S 1A4

We have developed an algorithm for predicting saccadic end-point during the initial 10-15 mS of the eye's movement. Such information is useful in high-resolution computer-graphics displays which update image areas based on anticipated eye-position. A better understanding of saccadic control strategies is also afforded. The technique can use a variety of models of the oculomotor plant to construct an estimate of the neural innervation driving the saccade. The reconstruction is then used as the basis for decoding the amplitude "intended" for the saccade. Decoding is achieved using both classical methods and newer parallel-distributed processing methods. Accuracy is greatest (1°) for saccades of less than 8°, above which amplitude more saccadic data is required for an accurate prediction. Questions of inter-saccadic variability and the implications of time-optimality of saccades will be addressed. The inverse problem of estimating the neural inputs which affect the accuracy of prediction will also be discussed. This presentation deals with prediction of horizontal saccades starting from primary position. Both adduction and abduction saccades are considered. Assumptions are not made about the triggering stimulus, as in real applications such information is not generally available. Generalization to vertical and oblique saccades, and those not starting in the primary position is considered.