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Disorders of Eye Movement

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The Influence of Drugs and Alcohol upon Human Eye Movement

Drugs, including alcohol, have a profound effect upon human eye movement. There are now several studies which have demonstrated this, and perhaps such observations are not surprising in view of the common clinical experience of the influence of present-day drugs on the motor system in general, such as the parkinsonian syndrome induced by the phenothiazine group of drugs and the cerebellar syndrome which occurs during anticonvulsant or alcohol intoxication.

The rapid movement of the eyes by which we change our gaze from one object of interest to another, placing the object of visual interest into the macular part of the visual field, is known as saccadic eye movement, each movement being called a saccade. Saccades are extremely fast movements, for example the eyes can be moved through an angle of 60° in about a tenth of a second. Though saccades are voluntary movements, their velocity is outside voluntary control. Saccadic velocity is not difficult to measure using modern electro-oculographic techniques. Alcohol, in a dose which produced blood alcohol levels between 80 and 100 mg/100 ml, reduced saccadic velocity by 17–19% (Wilkinson *et al.* 1974). In another study (Franck & Kuhlo 1970) vodka, given in a dose of 0.9 g/kg body weight, produced blood alcohol levels between 60 and 100 mg/100 ml one hour after ingestion and a 24% reduction in saccadic velocity. Two commonly used tranquillizers, chlordiazepoxide (Librium) and diazepam (Valium) have been shown to reduce saccadic velocity (Gentles & Llewellyn Thomas 1971). It was found that 30 mg of chlordiazepoxide and 5 mg of diazepam each reduced saccadic velocity by about 11%. It seems quite certain that alcohol and tranquillizing drugs, in moderate dosage, reduce the velocity of saccadic eye movements.

Smooth pursuit eye movements are those which enable a slowly moving target to be followed by the eyes, so that good macular fixation is kept upon such an object of visual interest. Normally the eyes can keep pace with targets moving with velocities up to 40° per second, but the ability to perform normal smooth pursuit movement is easily deranged by alcohol and drugs. Under the influence of such agents the eyes to tend to lag behind the object of interest as it moves, so that small corrective saccades are constantly required to keep the eyes near to the target. Good macular fixation is lost so that the target becomes blurred. With all the agents studied hitherto the effect upon following eye movement is clearly dose related, so that larger doses and higher blood levels are associated with more defective following movement and the occurrence of more gross and more frequent corrective saccades. Alcohol in doses which produced blood levels in the region of 100 mg/100 ml produced very severe impairment of smooth pursuit movement (Wilkinson *et al.* 1974); phenobarbitone, pentobarbitone and quinal barbitone all produced a marked dose-related effect (Norris 1968, Rashbass 1961), as did nitrazepam (Mogadon) (Norris 1971).

It is of some interest that doll's head eye movement, or oculocephalic reflex eye movement, by which fixation is maintained upon a stationary object during movement of the head, is not influenced by alcohol (Wilkinson *et al.* 1974) or barbiturates (Rashbass & Russell 1961) in doses which seriously impair smooth pursuit eye movement. Doll's head movement is a much more reflex affair than saccadic and smooth pursuit movement, depending upon incoming impulses to

the brain stem from the vestibular apparatus via the VIII cranial nerve and this sort of eye movement persists in man so long as the midbrain and brain stem are intact. Moderate intoxication with alcohol or barbiturates has no effect upon this reflex movement of the eyes.

The effect upon saccadic and following movements constitutes a repeatable and measurable biological effect of the above-mentioned agents in man. Though the agents which have been studied are tranquillizing, sedative and hypnotic by nature, the observed effects are not just due to induced drowsiness and lack of attention, since particular stress is given to the fact that the experimental subjects were maintained alert and interested throughout the study period. Saccadic and following eye movements require normal function of the cerebral cortex, midbrain and brain stem, and it seems likely that it is the effect of the drugs upon the cerebral cortex which is responsible for the impairment of saccadic and smooth pursuit movement since doll's head movement remains so normal under the same circumstances.

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Disorders of Ocular Movement in Hydrocephalus

It is a commonplace observation that ocular movements may be abnormal in patients with uncontrolled hydrocephalus but the pathogenesis of this abnormality, often referred to simply as the 'setting sun' sign, is controversial. West (1848) stated that 'the eyes are so displaced by the altered direction of the orbital plates, that the white sclerotic projects below the upper lid, and the iris (is) more than half hidden beneath the lower'. Until very recently this was the generally accepted explanation of these ocular signs (Oppenheim 1911, Ford 1966, Walsh & Hoyt 1969) although Pennybacker (1940) had observed the disappearance of similar ocular signs in 5 patients with adult-onset hydrocephalus, secondary to aqueductal stenosis, when the hydrocephalus was relieved by third ventriculostomy. Similar cases have since been reported by Petit-Dutaillis *et al.* (1950) and by Nag & Falconer (1966).

The development of effective surgical methods of treatment of hydrocephalus by ventriculoatrial CSF shunting has allowed the natural history of these ocular signs to be studied more closely. It has become apparent that, even in infants with gross hydrocephalic enlargement of the head, the maintained downward deviation of the eyes can be rapidly corrected by relief of the hydrocephalus. Indeed, in surgical practice, this is sometimes a useful index of shunt patency (Cogan 1956, Shallat *et al.* 1973). Attention has therefore been directed away from abnormalities of the roof plates of the orbits towards the central pathways mediating vertical gaze. I shall suggest, in this paper, that there are two distinct clinical syndromes of disturbed ocular movement associated with hydrocephalus, and shall discuss their mechanism:

(1) *Divergence with downward deviation:* The best-known ocular sign of hydrocephalus consists of resting conjugate downward deviation of the globes, usually with slight divergence. This abnormality is accompanied by impairment of volitional, optokinetic and oculocephalic conjugate upward gaze. The fact that both optokinetic and oculocephalic upward movements are affected indicates that both saccadic and pursuit vertical gaze systems are abnormal. Lateral and downward gaze are usually spared, but lateral rectus palsies may be present. In some patients there may be a few beats of nystagmus on lateral gaze and the pupils may be larger, and may react more sluggishly to light than normal.

(2) *Periaqueductal dysfunction:* In other patients, particularly those with childhood or adult-onset hydrocephalus in whom the head cannot enlarge because the cranial sutures have fused, signs suggestive of periaqueductal dysfunction can be elicited (Swash 1974). These may consist of the full sylvian aqueduct syndrome, first described by Koerber, Salus and Elschnig (Elschnig 1913) and later characterized by Kestenbaum (1946), or of fragments of this syndrome. The sylvian aqueduct syndrome consists of impairment of conjugate upward gaze; convergence nystagmus occurring as a substituted movement on attempted upward gaze; retractory nystagmus,