Clinical evidence for the onset of the sensitive period in infancy

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Abstract
Seven neonates had a IIIrd or Vth nerve palsy or afferent visual pathway pathology at birth. These abnormalities resolved within 6 weeks and the children have developed normal visual acuity, motor fusion, and stereopsis. We conclude that there is a latent period of 6 weeks before the onset of the sensitive period.

The neonatal visual system is anatomically, physiologically, and functionally immature at all levels from the eye to the striate cortex and the brain stem and pontine eye movement control centres. For example, most neonates show a constant or intermittent exodeviation and the visual evoked potential is not cortically mediated. The process of maturation whereby normal visual acuity, motor fusion, and stereopsis is achieved takes place over several years. There is behavioural evidence to suggest that sensory stereopsis is established in most infants at 20 to 28 weeks indicating that the receptive fields of binocularly driven striate cortical cells have been established in corresponding positions on the two retinas by that age. However it is not clear at what age after birth the sensitive period for maturation begins.

Neonatal and infantile visual physiology have been extensively investigated experimentally. For example, kittens are born with both eyes closed and under normal circumstances one may open up to 6 days before the other. However, provided both open by day 12 normal binocularity develops. A unilateral lid suture even for a period as short as 7 days after day 12 will result in amblyopia of the occluded eye and absent binocularity, indicating that the sensitive period for the competitive development of cortical binocularity has begun. It is established by such experiments that after the latent period there is a sudden onset of sensitivity to visual deprivation in the cat, a period of high susceptibility, and then a slow decline. The same maturational process is seen in other animals. For example, the latent period before the onset of binocular competition and the sensitive period in monkeys is about 21 days.

In man the latent period is less well defined. Experience with unilateral congenital cataracts is conflicting. There is evidence to suggest that good visual results are achieved only with surgery in the first few days of life, indicating a very early onset of sensitivity, although other studies have shown visual acuities of 6/12 or better in those operated on before 17 weeks. None of these children achieved binocularity.

We have studied a group of seven children with either afferent (two cases) or efferent (five cases) abnormalities of the visual system present at birth, but spontaneously resolving over the first few weeks of life. The subsequent development of normal vision and binocularity in these children provides evidence for a latent period of up to 6 weeks before the onset of the sensitive period in infancy.

Patients and methods
The seven children were referred as neonates over a 4-year period and all were examined in the first week of life. (see Table 1). Apart from case 5 who had meningitis, none received any systemic or local treatment. Case 6 had retinal haemorrhages at the posterior pole of the left eye, discovered when the patient was examined because of a constant left exotropia. The eye showed poor fixation but the haemorrhages disappeared by 6 weeks, fixation improved, and the exotropia gradually resolved. All the infants were observed at frequent intervals so that the period before resolution of the abnormality (for example restoration of full fixation movement) was accurately measured.

Orthoptic examination consisted of clinical assessment of fixation and visual function with acuity when possible, cover test at near and distance fixation (including 4 dioptrre prism fusion test) and assessment of eye movements, motor fusion, and stereopsis. Motor fusion was assessed using base-out prisms of 15 and 20 dioptres. Stereopsis testing was with the Lang test for all children and the Randot test for older patients.

Results
The results are given in Table 1. 'Lang positive' indicates an unequivocally positive behavioural response to the Lang random dot stereotest. In summary, in all seven children the abnormalities

<table>
<thead>
<tr>
<th>Patient</th>
<th>Sex</th>
<th>Date of birth</th>
<th>Lesion</th>
<th>Other</th>
<th>Time to resolution (weeks)</th>
<th>Orthoptic assessment (with age)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>16.6.86</td>
<td>L V1th</td>
<td>Nil</td>
<td>6</td>
<td>Normal (5 years). Normal Snellen acuity. Stereopsis to 30 seconds Normal (1 year 6 months). Lang positive</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>27.3.90</td>
<td>V1th</td>
<td>Forceps delivery. Subconjunctional haemorrhage right eye</td>
<td>5</td>
<td>Normal (1 year 6 months). Lang positive</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>9.1.90</td>
<td>R V1th</td>
<td>Forceps delivery</td>
<td>4</td>
<td>Normal (1 year 6 months). Lang positive</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>9.1.89</td>
<td>R V1th</td>
<td>Nil</td>
<td>4</td>
<td>Normal (2 years 6 months). Vision equal. Lang positive</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>14.3.90</td>
<td>R IIIrd</td>
<td>Neonatal meningitis</td>
<td>6</td>
<td>Normal (1 year 6 months).</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>2.6.90</td>
<td>L retinal haemorrhage</td>
<td>Exotropia</td>
<td>6</td>
<td>Normal (15 months)</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>4.12.90</td>
<td>R lid haematoma</td>
<td>Forceps delivery</td>
<td>5</td>
<td>Normal (10 months)</td>
</tr>
</tbody>
</table>
Discussion
The robustness of the innate capacity for the development of binocularity is illustrated by its frequent normality in infranuclear abnormalities that seriously derange eye movements such as Duane’s syndrome or congenital IVth nerve palsy. However, in these examples binocular alignment is possible in certain positions of gaze, while before the development of head control, a complete lateral rectus palsy means ocular alignment is never possible. The period of misalignment had no effect on the normal development of binocularity in the four children with lateral rectus palsies that we studied. This indicates that the sensitive period must have started after the recovery of full eye movements at between 4 and 6 weeks of age, otherwise the affected eye would have been amblyopic and cortical binocularity impossible. This finding is consistent with previous reports of neonatal lateral rectus palsy and underlines the benign nature of the condition.

By contrast, a post-viral abducens palsy lasting 4 to 6 weeks in an older child is a predictable and potent cause of amblyopia. Similarly, in the girl with neonatal meningitis and a partial IIIrd nerve palsy, the restoration of full eye movements by the age of 6 weeks has been followed by normal visual development. Failure of recovery of normal eye movements in congenital IIIrd nerve palsy always results in profound amblyopia and absent stereopsis even after early surgical treatment. The two children with afferent abnormalities recovered anatomical normality by the age of 6 weeks and developed normal visual acuity in the ‘occluded’ eye and normal binocularity.

Most of these seven children are not yet old enough for a full assessment of their binocular status to be made. However, considering the seriousness of the pathology at birth, the absence of clinical abnormality suggests a latent period of between 4 and 6 weeks after birth before the onset of the sensitive period.

Defining the latent period is important for several reasons. Firstly, it validates in man the model of the developmental neurophysiology of binocularity resulting from work in experimental animals. Secondly, it is relevant to the aetiology of infantile strabismus. The large angle esotropia characteristic of this condition is not present at birth and is usually noticed from the 6th-8th week onwards, sometimes initially intermittently. Our findings indicate therefore that the onset is within the first few weeks of the sensitive period. The esotropia could be a motor response to a failure of normal competitive afferent visual interaction. Its occurrence when susceptibility to disruption is maximal may explain the failure to develop high grade binocularity even with very early surgical realignment. Thirdly, the onset of the sensitive period is of practical importance in the management of individual cases such as those presented and others, for example, unilateral congenital cataract. The evidence suggests that surgery for a visual result should be timed to achieve optical correction by the age of 6 weeks.

References: