Measurement of Ocular Dominance- A Comparison of Methods and Results

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Introduction

The dominant eye has often been defined as the eye whose input is favoured in behavioural co-ordinations where only one eye can be used. The eye preferred when monocular views are discrepant. Patterns of ocular dominance have been shown to be related to a large number of perceptual, performance and clinical phenomena.

A consideration of eye dominance has a bearing on the fundamental visual skills of aiming and anticipation (depth perception), especially relevant in sport. Whether learned or innate, it may predispose an individual to a particular sport. The increasing links to learning difficulties etc. indicate that ocular dominance should be part of the overall assessment of all our patients.

Most measures commonly used to ascertain and define eye dominance are based on sighting/aiming tests or binocular rivalry/sensory dominance testing. There have to a lesser extent been other methods, such as motoric efficiency tests, which may give additional viewpoints but are less prominent.

A presentation at Sportsfair 08 by Gail Stephenson on the role of ocular dominance in soccer and her findings of a ‘central dominance’, especially in elite players, indicated that further research into the different methods was needed.

Methods

A measurement of eye dominancy was first recorded by Porta in 1893 using a pointing test. The subject aligned their finger with a distant object while keeping both eyes open. They closed one eye and then the other to see which eye was being used to view the object.

There are only scattered references to a ‘dominant eye’ and its detection until the 1920s when Miles devised his ABC Test (this also controlled for handedness). This became the basis of the most widely used sighting dominancy tests up to the present day. In its original form, subjects held a truncated cone to cover their faces, kept both
eyes open, and aimed at a distant object. The subject aligned the cone with one of their eyes, usually without realising it. Present day variations include, ‘hole in the card’ or ‘hole in the hand’ tests.

Over the years, many studies have explored sighting dominance using large samples. They are remarkably consistent in their results, irrespective of age or ethnicity. On average, 65% sight with the right eye, 32% sight with the left eye and 3% show no consistent pattern.

The majority of these sighting dominancy tests in use represent situations in which both eyes cannot be simultaneously used. They force the subject to choose right or left eye to view with, and do not permit a more central representation of ocular sighting dominance.

In 1998, Romano\(^2\) used an adaptation of Porta’s pointing test to assess eye dominance in baseball players, but used a camera to assess and record alignment of eye and finger. His results found, in a normal control population (with good visual acuities and stereopsis), the expected proportion of right and left dominance, but also found the presence of 16% showing a ‘central dominance’. The percentage showing a central dominance rose to 26% when assessing University of Florida Varsity baseball players and he noted that those individuals with ‘central ocular dominance’, whether right or left handed were classed as the most successful players in both pitching and batting. (Incidentally he also found that crossed hand eye dominance was twice that of his normal control group.)

In the case of Gail Stephenson and the Manchester United players (Stephenson 2007\(^3\)), she used an adaptation of the Romano method above, but took five photographs of each subject and categorised the results as Right, Right central, central, Left Central and Left. She assessed a hundred players between the ages of 15 and 30 years, over a three year period. In the more skilled soccer players, determined by the frequency of First Team selection, the incidence of a central result was 94%. The incidence reduces in younger or less skilled players. She found similar results in netball and hockey; but not in sports where carrying the body
through space is not a requisite.

In normal viewing with both eyes open we are totally unconscious of what we are seeing with the two eyes. We cannot voluntarily choose to see with either eye. However eye dominance normally refers to a monocular preference when monocular images cannot be fused or monocular viewing is required. The alternative methods based on binocular rivalry/sensory dominance may give further information of the strength and types of ocular dominance present.

One of the latest methods to assess eye dominance in this way is to utilise rapid serial visual presentations (Valle-Inclau 2008). This consists of presenting dichoptically (separately to each eye) two streams of randomly selected alphanumerical characters at rates of around 5hz (i.e. 200 milliseconds per presentation) and asking observers to detect a particular character embedded in each stream. The observers view a colour monitor through a mirror stereoscope so that each eye can see only half of its screen. Under these conditions many observers are never aware that two characters are being presented, i.e. there is complete suppression of one of the monocular channels. The majority of observers missed targets presented to one of their eyes and detected all targets presented to the other eye. Some observers did however observe the monocular stimuli as superimposed and some could detect all targets with both eyes. The inter-ocular differences statistically correlated well with sighting dominance scores obtained with the ‘hole in hand’ method performed in the same observers. This method not only allows a grading of direction and strength of eye dominance, but also the presence of no dominance/central dominance. It also totally eliminates the effect of handedness that can affect sighting tests. The average of other studies that have employed binocular rivalry / sensory dominance indicate that 50% of combined samples showed preference for the right eye, 31% for the left eye and 19% were ambiocular (a very similar % showed central dominance in Romano’s control group).

In Practice Comparison of Methods

A small sample of subjects were tested to see how different subjects would respond to the different tests. All the subjects had normal binocular vision and were right handed.

A hole in the hand test was performed five times, crossing hands each time. A bi-manual pointing test, utilising a camera to measure eye alignment was performed three times, and also separately once with the right and then once with the left hand pointing. A binocular rivalry test utilising a +1.75 blur lens was performed. (With the advent of computerised test charts it would be relatively simple to incorporate a rapid serial visual presentation test, utilising a polarised filter, for sensory dominance testing).
Results

<table>
<thead>
<tr>
<th>Hole in the hand</th>
<th>Pointing with 2 hands</th>
<th>Pointing with R hand</th>
<th>Pointing with L hand</th>
<th>Degree of visual upset + 1.75DS R eye</th>
<th>Degree of visual upset + 1.75DS L eye</th>
</tr>
</thead>
<tbody>
<tr>
<td>LLLLL</td>
<td>LLL</td>
<td>L</td>
<td>L</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>RRRRR</td>
<td>RRR</td>
<td>R</td>
<td>R</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>RRRRR</td>
<td>RRR</td>
<td>R</td>
<td>R</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>LLLLL</td>
<td>LLL</td>
<td>L</td>
<td>L</td>
<td>2</td>
<td>6</td>
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<tr>
<td>RRRRR</td>
<td>CCC</td>
<td>R</td>
<td>L</td>
<td>7</td>
<td>8</td>
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<tr>
<td>RRRRR</td>
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<td>LLLLL</td>
<td>CCC</td>
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<td>7</td>
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</table>

The subjects that showed an obvious central dominancy on the pointing test, also noted an almost equal and marked blur when the +1.75Ds was applied to either eye.

Discussion

This review of methods and results overwhelmingly reveals the existence of a dominant eye, but there may be several important forms of ocular dominance and different levels at which it is being measured.

Stephenson prefers to use the term ‘localisation’ when discussing her measurements and her form of dominancy testing may be measuring the interpretation of the body’s position in space, with emphasis on its relation to other objects, from the visual clues received.

We cannot normally voluntarily choose to see with either eye. Instead we fuse and combine all binocular information into one sensory whole view of the world about us. This one sensory whole has been labelled the ‘Binoculus’ and has been described as a cyclopean view.

Romano\(^7\) argues that the only true physiological test for ocular dominance is a pointing test. Pointing, preferably bimanually, with extended arms and both eyes open, at either a single open eye of the observer or preferably the centre of a camera lens. This allows one to precisely locate the binoculus and allows the determination of a central form of ocular dominance, one in which neither eye is dominant.

Most of the ocular sighting dominance tests do not allow for the determination of a state of central ocular dominance, so such a category has not really been isolated or studied before Romano or Stephenson.

It would be assumed, in the presence of binocular vision and fusion, that the ‘cyclopean’ eye would most naturally be located centrally, with central ocular dominance the normal state of affairs. However, as seen in the above results, and in both studies, only a minority of individuals exhibit this tendency, except in the case of
the elite players.

Whether such central dominant subjects would see both dichoptic streams on sensory dominance testing would make interesting research. My own small sample did indicate this as a possibility. A further study with larger groups, utilising a rapid serial visual presentation method to test for sensory dominance may or may not confirm this link.

Conclusion

The SportVision Association has collected data from many elite groups of athletes and has found interesting patterns emerge in eye dominance, dependant on the sport being investigated and rarely does it follow that of the general population. The findings of Romano and Stephenson, of a form of 'central' dominance in the very elite players, underline the role that dominance has to play and that measuring it in its different guises can be informative.

Whether people of a certain dominance are predisposed to certain sports, or whether once they are involved in a sport a particular configuration develops remains to be seen. The general consensus has been that eye dominance is genetically determined\textsuperscript{8-9} and cannot be easily manipulated\textsuperscript{10,11} but when it is disturbed due to refractive or pathological changes (our role to prevent!) it does cause significant problems.

A seven year longitudinal study is presently being undertaken by Gail Stephenson to see if the players, initially assessed as R or L dominant, become more centrally dominant with the intensive training programme they are subjected to, both on and off the pitch.

Assessment of eye dominance in all its different guises would appear to have significant relevance especially in sport and may allow guidance as to what sport to concentrate on, what stance or position to play, and maybe what level might ultimately be achievable.

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