Match! Finding the best lenses for sport part one

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Competencies covered:
Dispensing opticians: Communication and Refractive management
Optometrists: Communication, Assessment of visual function and Binocular vision

Understanding the relationship between vision and sporting performance is the precursor to knowing how and what lenses (including contact lenses) and frames to dispense.

This in turns requires understanding the normal physiology of the athlete (ocular and systemic), which includes vision and the demands of the sport given by the visual task analysis. This article in two parts, proposes a new approach to the science of vision in sport. It aims to clinically justify the dispensing, which is as important to the final outcome as the refraction and eye examination.

Part 1 The Science
Eye Dominance and Sport - Introduction

The link between vision and its effect on sporting and occupational performance is scientifically weak (for instance the driving standard is not scientifically proven[1,2]). Understanding ocular dominance may help to establish this link.

The measurement of eye dominance is established[3] and seems to parallel the asymmetry of the brain that is broadly divided into left and right hemispheres, having different and complementary functions[4].

The consideration of ocular dominance in sport is often anecdotal and is understood in the context of aiming. Various terms are used to describe dominance including sensory[5] and ocular[6] and each has its own method of measurement. In rifle shooting eye dominance is measured by methods, which often vary from coach to coach[7] but is usually found to be the eye which gives the best results when placed behind the near sight of the rifle in line with the foresight (on the end of the barrel of the gun) and the target **(Figure 1)**. Sport only differs from other occupations, in its diversity and the level of visual demand[8], and it is likely that the aiming process, to a greater or lesser extent will contribute to success in sport and perhaps less critically in all other occupations[9].

The relationship between hand and eye dominance

During the years of its development Sportvision has collected data from many elite groups of athletes and one of the many interesting patterns that emerge is the relationship between specific sports and hand and eye dominance[9]. The data confirms that eye dominance is not an infallible predictor of hand dominance and that the incidence of hand eye dominance varies from sport to sport **(Table 1)**. This relationship appears to be important and may predispose to particular sports.

Hypothesis

The measurement of eye dominance may provide the basis for a mechanism to demonstrate the relationship between vision correction and sporting performance contemporaneously, where early longitudinal research based on eye exercises and therapy could not[10,11].

It was proposed that fogging (blur) of the dominant eye would have an adverse effect on the ability to aim at or hit the target even without a reduction in binocular vision. Aiming is used in its broadest sense to include ball catching, kicking a football at the goal, car racing (aiming at the crown of the bend) as well as in target sports.

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Figure 1: Traditional aiming *(Courtesy Graham Oades)*

Figure 2: Finding the dominant eye

Figure 3: The Lobster

It was also proposed that racket sports would be affected in the same way, although it was difficult to say how aiming happens when a lining up of ball, racket and eye does not usually occur.

Subjects

To test this hypothesis a group of international tennis players and a group of club and National Clay target shooters, each with an average age of around 43 **(Table 2)**, were compared.

Tennis

Players were tested during the Marsh Classic at the Hurlingham Club, Fulham (18.02.2002.); 13 players on the masters' circuit, including winners and finalists at Wimbledon, the Australian, French and US open championships.

Clay target shooting

Shooters at the Braintree Clay target-shooting club were tested (22.06.2002); 12 shooters were assessed.

Method

Both groups were asked to say with which hand they wrote and with which foot they kicked a ball. Their high contrast LogMAR vision was measured as they presented to play their sport with or without correction. Eye dominance was measured using The Sportvision Dominance Test (a hand over hand method **(Figure 2)** to eliminate left right bias[9]); this gave four readings of eye dominance, eg RRRR.

Experimental procedure - tennis

The tennis players who were all right handed stood on the half way line of the court and received volleyed balls from a machine **(Figure 3)** at about chest height, delivered from the service line. The speed and direction were reasonably consistent but not entirely predictable.

Each player wore three sets of plano sporting goggles. The first pair was clear, the second pair had the right eye fogged with Bangerter foil[9] to about 6/15 and the third pair had the left eye fogged **(Figure 4)**.

Wearing each pair of goggles in turn the players had to direct 10 deliveries (30 altogether) onto an archery target at a distance of about 3 metres, placed at 90 degrees to the direction of the ball **(Figure 5)**. The clear goggles were used first to try to

Figure 4: Fogging goggles

Figure 5: Player and researcher position

Dominance		Cricket	Archery		Football	Rifle
Eye	Hand	Scottish National	Inter-nationals	Coaches	Leyton Orient	GB Junior Squad
		N = 15	N = 16	N =70	N = 18	N = 32
Right	Right	46.7	62.5	84.3	55.5	87.5
Left	Left	6.6	18.75	10	11	3.1
Right	Left	6.6	6.25	2.85	16.7	0
Left	Right	40	12.5	2.85	16.7	9.4

Table 1: Incidence of hand / eye dominance in elite sport %

	Tennis	Clay Shooting
Sample size (N)	13	12
Av Age	43.6	42.3
Av Years Playing	36.2	14.2
Specs dist or near (%)	42.8	46.1
Contact lens wear (%)	21.4	7.8
Reported difficulties (%)	50	84.6

Table 2: Demographics

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Figure 6: Left eye aiming

	Shooting	Archery		Tennis
	Target: The clay	Target: an archery boss		Target
		Gold	Whole target	The court
Target size cm	11	16	80	400
Distance	3000	300	300	1800
Tangent	0.0037	0.0533	0.2667	0.2222
Angular subtense	12 minutes	3 degrees	15 degrees	12° 33'
Archer target (gold) Vs size of clay		15 x bigger		
Whole archery Target Vs size of clay		75 x bigger		
For comparison in a 10m pistol target the bull is 1cm in diameter, which gives an angular subtense at the eye of tan 1/1000 = 3.4 Minutes				

Table 3: Target size and angular subtense at the eye

minimise the effect of learning on significance in the second and third sets of trials.

All the players were right handed so they had to play a forehand shot to their left to hit the boss. The target was divided into four scoring areas, the centre yellow and red scoring three, two for the blue and black and one for the white, a complete miss, scored zero.

Experimental procedure - clay target shooting

The shooters had 10 trials in each pair of goggles, 30 in total. Their target was a clay launched straight towards them from a distance of about 30 metres. A hit scored one and a miss scored zero. All shooters were asked to keep both eyes open but one shooter had to close his left eye at the point of firing **(Figure 6)**.

Target size

A consideration of the skills in an individual sport (occupation) needs to take into account the target size and speed (visual task analysis). The angular subtense at the eye of the clay at 30m being much smaller than say the static archery target at 3m **(Table 3)**.

Results

Vision as the athletes presented was 0.0 LogMAR or better in most subjects **(Table 4)**.

Incidence of eye hand dominance **Table 5** shows the incidence of hand eye dominance in tennis and clay target shooting.

The incidence of eye dominance in these groups does not conform to the previously tabulated sports. This is more surprising in the Clay Shooters whose sport to the lay observer is apparently similar to rifle shooting.

Effect of monocular blur (fogging) Shooting

Using the data for the whole group monocular blur (dominant or non-dominant eye) had no significant effect on score compared with no blur **(Table 6)**.

This was unexpected (the hypothesis was that blurring the dominant eye would adversely affect the scoring in Clay target shooting), but when the athletes were divided into groups according to eye dominance and handedness some results became significant.

The results when the dominant eye was occluded were significantly worse in shooters who were right eye dominant right handed and right footed, when they were separated from everyone who had a left tendency in hand, eye or foot. This left tendency included a single left response in the eye dominance test for example RRLR or a tendency to ambidextrousness in hand or foot. The resulting two groups were defined as Type 1 Dominant (Right eye, hand and foot) and Type 2 Dominant (any left tendency): see **Table 7**.

Table 4 :Vision in Tennis and Clay target shooting

Sport	Tennis		Clay shooting	
Eye	R	L	R	L
LogMAR Vision 90%	-0.1	-0.2	-0.1	-0.22
	-0.2	-0.18	0.1	0.08
	-0	-0.2	-0.2	-0.2
	0.2	0.2	0	0
	-0.1	-0.12	-0.12	-0.12
	0	-0.1	-0.2	-0.2
	-0.2	-0.2	-0.3	-0.26
	-0.1	-0.1	0	0.2
	0.12	-0.18	-0.1	-0.1
	-0.1	-0.1		
	-0.1	-0.1	-0.24	-0.28
	-0.1	-0.1	0.02	0.1
	-0.1	-0.1	-0.26	-0.22
Average (Mean)	**- 0.06**	**- 0.11**	**- 0.117**	**- 0.102**
% Eyes worse than 0.0 (6/6)	7.7 (1)	7.7 (1)	18 (2)	25 (3)

Table 5: Incidence of hand eye dominance in tennis and clay target shooting

Eye	Hand	Tennis % (N = 13)	Clay Shooting % (N =12)
Right	Right	57.1	46.1
Left	Left	0	7.6
Right	Left	28.6	15.4
Left	Right	14.3	30.8

Shooting	P whole group
No blur Vs Dom blur	0.21
No blur Vs Non D blur	0.25

Table 6: Significance of monocular blur in shooting (N=12)

Shooting	Type 1	Type 2
No blur Vs Dom blur	0.0057	0.139
No blur Vs Non D blur	0.38	0.161

Table 7: Significance of monocular blurring in shooting Type 1 (n=6) Vs Type 2 (n=6)

Tennis	P
No blur Vs Dom blur	0.0186
No blur Vs Non D blur	0.0012

Table 9: Effect of monocular blur in Tennis

	Type 1 Score		Type 2 Score		P
Shooting	Total	Mean/shot	Total	Mean/shot	T1 Vs T2
No Blur	63	0.9	40	0.67	**0.00047**
Dom Blur	53	0.76	45	0.75	0.46
Non Dom Blur	64	0.91	35	0.58	**0.00043**

Table 8: Shooting Scores Type 1 Vs Type 2

Tennis p	Type 1 (n=7)	Type 2 (n=5)
No blur Vs Dom blur	0.0057	0.32
No blur Vs Non D blur	0.0018	0.12

Table 10: The effect of monocular blur in Type 1 Tennis players

Type 1 was affected by blurring the dominant eye and Type 2 unaffected, despite Type 1 being significantly better than Type 2 with no blur and with their non-dominant eye blurred **(Table 8)**.

Tennis

For the whole group blur in either eye significantly worsened the score, but the significance was unexpectedly greater when the non–dominant eye was blurred **(Table 9)**.

When the group was divided into Type 1 and Type 2 the greater significance of non-dominant blur was shown to be due most to the Type 1 players **(Table 10)**. The Type 2 players also showed a tendency to be affected when their non-dominant eye was blurred, but this was not significant.

Discussion

Eye dominance and aiming

Anecdotally the dominant eye is used as the aiming eye but it is not clear in some sports how the aiming process is carried out or even if there is an aiming skill involved in the traditional sense.

The results show that eye dominance as measured by the hand over hand method is important in aiming in clay target shooting but only in Type 1 dominant shooters. Type 1 shooters were the most proficient so it may be safe to suggest that:

- Stable right eye dominance in Type 1 shooters predisposes to the highest scores.
- The hand over hand method of measuring eye dominance is useful in separating Type 1 from Type 2 dominance as determined by the significance of the result.
- Aiming is important in Clay target shooting and this is best carried out by the dominant eye
- An induced fogging or blur in the dominant aiming eye has a significant effect on the Type 1 shooters ability to hit the target
- This induced fogging could be related to acquired or congenital ametropia, which is susceptible to optometric correction

Although the Type 2 shooters were not so proficient they also showed a tendency to this dominant eye effect, which could become significant with more subjects. It does raise the question why are they less affected when their dominant eye is blurred in a sport, which is supposedly reliant on the aiming process

Clay and tennis compared

Unexpectedly the tennis results for the whole group showed that blurring in either eye reduced the score and the effect was greater when the non-dominant eye was blurred; so the hypothesis that blurring the dominant aiming eye in tennis would have the greatest effect on the ability to hit the target has to be rejected. Blurring the non-dominant eye had the greatest effect and again like the clay shooters this effect was mainly due to Type 1 players.

The effect of the non-dominant eye

One explanation why blur in the non-dominant eye in tennis has the greater effect could be that it is not an aiming sport in the traditional sense but one that is more dependent on depth perception, Depth perception is used to anticipate the arrival of the ball, by judging its speed of approach. It is likely because of the stability of eye dominance in Type 1 that stereoscopic depth perception is well developed and the predominant skill.

This could explain why Type 1 is worst affected by non-dominant blur. A strongly dominant right eye would be relatively less affected when blurred and working with the left eye, whereas when the left eye is blurred in Type 1 the strong dominant right eye would overwhelm the visual system and make the player relatively monocular. The effect on stereoscopic judgement would therefore be more marked when the non-dominant eye is blurred.

The mystery of Type 2 could be understood in terms of less well-established eye dominance and a reduced level of stereoscopic vision. Developmentally Type 2 would have to learn to rely more on monocular clues for depth judgement and therefore be less affected by the blur in one or other eye.

This in turn would make the Type 2 visual system more robust and less susceptible to ametropic deficit, but at the same time be less finely tuned to the requiements of the most visually demanding sports. This is shown by the better shooting skills for Type 1 in clay target shooting **(Table 8)**.

Another question now is why the incidence of Type 1 shooters is lower in an aiming sport like Clay target shooting than it is in rifle shooting, two

Continued overleaf

factors may explain this:
1. Clay shooting may not be an entirely aiming sport and some depth perception is required; judging the speed of the clay depends on knowing how far it is away. As long as both eyes work well together depth perception will be relatively unaffected by being left or right eye dominant. What clay shooters lack in aiming precision (the precision required is less than in rifle shooting {angular subtense of the target as well as the scatter of the shot}), could be made up by another compensatory skill.
2. The other compensatory skills in Clay are peripheral awareness required to pick up the flight of the clay and power to control the movement of the gun. It is likely that in all sports where one skill is reduced another will be enhanced. This will achieve a balance in all sports of skills like power (speed and strength), reaction time and endurance, as well as vision.

Summary

It could be considered that acquired or congenital ametropia as mimicked by the blur of the Bangerter foil, has a significant effect on the ability to shoot or play tennis. The degree of disability depends on whether the athlete is Type 1 or Type 2 Dominant.

The two sports of clay target shooting and tennis demonstrate two primary visual skills in sport of aiming and anticipation (based on depth perception). It may be that all sports can be considered in terms of the proportions of these two visual skills. Visual performance could thereby be used to predict to which sport individuals might be better suited, taking into account other physical attributes (for example weight and height).

This prediction would be informed by the overall visual demand (visual task analysis) as the different target sizes in clay target shooting, rifle shooting and tennis suggest.

In sports where the primary visual skill is anticipation the aiming skill is likely to be subliminal and the target size big. In tennis the markings of the court and the net provide a peripheral fix for body position, to return shots. In clay shooting the relatively small target ensures a high degree of aiming is required.

From the findings the following principles are proposed:
1. The primary visual skills in sport are aiming and anticipation, upon which all other skills are based.
2. Visual performance is the controlling external factor* in the development and maintenance of sporting performance throughout life.
(*Other external factors that can be influenced by coaching procedures include physical training, physiology, nutrition and psychology).
3. Sporting performance is more or less dependent (according to the visual requirements of the sport) on the maintenance of the normal, established relationship between the two eyes (binocular vision).
4. A deficiency in visual performance will inhibit the development of sporting potential through poor eye / hand / body co-ordination

The dispensing implications are that visual information has to be maximised on a stable platform (the sporting appliance) and this will have a direct effect on sporting performance. For higher prescriptions or anisometropia, when there is a differential prismatic effect or aniseikonia, contact lenses might be prescribed with or without the sporting appliance.

Conclusion

It seems that vision may affect sporting performance in the most direct way, the ability to hit the target. This could be equated to making a pass in football or netball or scoring a goal, where the target may be a player, an area of the pitch, or the space between the goal posts. In life refractive change can be insidious and the subject may be unaware of the deficiency and its effects on aiming, stereopsis and competitive performance.

It would follow that the eye examination, refraction and dispensing are equally important to maximising sporting performance and vision may be the most important consideration in the preparation for competitive sport.

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