

## GUEST EDITORIAL

**Hypermetropia or hyperopia?**

A recent suggestion by a reviewer of a manuscript that the use of the word 'hypermetropia' was incorrect and that it should be replaced by 'hyperopia' caused us to look again at the literature of the subject to see if this criticism was justified. The background is an interesting one.

Myopia has been clearly recognised since classical times. Aristotle (384–322 BC) gives a concise description of the myope's tendency to partially close the lids to form a stenopaic slit in order to improve their vision of distant objects: the name myopia (μύω I close; ὠψ the eye) was apparently given by Galen (ca. 130–210 AD). However, a proper understanding of hypermetropia (υπερ larger + μέτρο the norm + ὠψ the eye) had to await the work of Donders, in Utrecht, Holland (Figure 1).<sup>1,2</sup> As Donders discusses in his historical review of the topic (Donders,<sup>3</sup> pp. 325–331), much of the problem was caused by confusion between the effects of presbyopia and hypermetropia on near vision. Since both could be corrected with converging lenses, they had been generally grouped together using a variety of terms such as far sight, long sight, hyperpresbyopia or over-sightedness (*Uebersichtigkeit*).

Donders openly acknowledged that many previous authors had anticipated aspects of his own efforts to differentiate between hypermetropia and presbyopia, but pointed out that their ideas had failed to gain widespread recognition and acceptance.<sup>3</sup> Notable is a paper by the Englishman, James Ware (1813),<sup>4</sup> in which he states:

There are also instances of young persons, who have so disproportionate a convexity of the cornea or crystalline, or of both, to the distance of these parts from the retina, that a glass of considerable convexity is required to enable them to see distinctly, not only near objects, but also those that are distant; and it is remarkable, that the same glass will enable many such persons to see both near and distant objects; thus proving that their defect of sight is occasioned solely by too small a convexity in one of those parts above-mentioned, and that it does not influence the power by which their eyes are adapted to see at distances variously remote. In this respect such persons differ from those who have had the crystalline humour removed by an operation; since the latter always require a glass to enable them to discern distant objects, different from that which they use to see those that are near.

Clearly, although both groups benefit from positive corrections, Ware<sup>4</sup> is differentiating the problems of young hypermetropes, who still have active accommodation, from

those of aphakes. Unfortunately, these comments by Ware failed to excite the attention of his contemporaries.

Donders evolved his own classification of spherical refractive errors and their correction over a period of several years. In 1858 he was still considering<sup>5</sup> the problems under the heading of hyperpresbyopia but by 1860 he was stating firmly:

*'In Bezug auf den fernsten Punkt des deutlichen Sehens zerfallen mithin die Augen in drei Klassen: (1) in normale oder emmetropische für parallele Strahlen, (2) in myopische (brachymetropische) für divergierende Strahlen, (3) in hypermetropische für convergierende Strahlen eingerichtet.'* [Light from the far point for clear vision falls on the eye in 3 ways: (1) in normal or emmetropic eyes as parallel rays, (2) in myopic (brachymetropic) eyes as divergent rays, (3) in hypermetropic eyes as convergent rays].<sup>6,7</sup>

Donders elaborates on these ideas in his magisterial 'On the Anomalies of the Accommodation and Refraction of the Eye' (Donders<sup>3</sup>, pp. 81–83):

With regard to refraction, we call the structure of the eye normal, when in a state of rest, it brings the rays derived from infinitely distant objects to a focus exactly on the anterior surface of the layer of rods and bulbs [cones]; in other words, when parallel incident rays unite on that layer (in  $\phi$ " Figure 51 [Figure 2a]). The farthest point of such an eye lies at an infinite distance. If convergent rays are also capable of being brought to a focus, the eye possesses something which it does not need: for from all objects proceed divergent or at most parallel rays. If on the contrary, the farthest point lies not at an infinite, but at some finite distance, vision is indistinct throughout a great part of the space. Consequently the refraction of the media of the eye at rest can be called normal in reference to the situation of the retina, only when parallel incident rays unite on the layer of rods and bulbs. Then, in fact, the limit lies precisely at the mean; then there exists emmetropia, (from ἐμμετρος, modum tenens, and ὠψ, oculus). Such an eye we term emmetropic.

This name expresses perfectly what we mean. The eye cannot be called a normal eye, for it may very easily be abnormal or morbid, and nevertheless it may be emmetropic. Neither is the expression normally constructed eye quite correct, for the structure of an emmetropic eye may in many respects be abnormal,



**Figure 1.** Frans Cornelius Donders, 1818–1889.

and emmetropia may exist with difference of structure. Hence the word emmetropia appears alone to express with precision and accuracy the condition alluded to.

Emmetropia then is met with, when the principal focus of the media of the eye at rest falls on the anterior surface of the most external layer of the retina (compare Figure 51 [Figure 2a]). This is the simplest definition.

The eye may deviate from the emmetropic condition in two respects: the principal focus  $\phi''$  of the eye at rest may fall in front of (Figure 52 [Figure 2b]) or behind (Figure 53 [Figure 2c]) the most external layer of the retina. In the former case divergent (dotted in Figure 52 [Figure 2b]), in the latter convergent rays (dotted in Figure 53 [Figure 2c]) come to a focus on the retina. In the first case, therefore, in the condition of rest, objects are accurately seen which are situated at a definite finite distance (Figure 52i [Figure 2b]); in the second they are at no distance accurately seen, for the rays in falling upon the cornea must, in order to unite in the retina, already converge towards a point situated behind the eye (Figure. 53i [Figure 2c]). In the first case the farthest limit lies within the normal measure: the measure is too short, and the condition might, therefore, be called brachymetropia [short – measure –

the eye]. In the second case, the boundary lies beyond the measure, and I have, therefore, called this state hypermetropia [in excess – measure – the eye].

Hence it is perfectly clear, that brachymetropia and hypermetropia are two opposite conditions.

The definitions are now extremely simple: the posterior principal focus  $\phi''$  of the media of the eye at rest falls:—

- in EMMETROPIA on the most external layer of the retina;
- in BRACHYMETRETROPIA in front of the most external layer of the retina
- in HYPERMETROPIA behind the most external layer of the retina

In order to express that the eye is not emmetropic, we may use the word ametropia (from  $\acute{\alpha}\mu\epsilon\tau\rho\omicron\varsigma$ , extra modum, and  $\acute{\omega}\psi$ , oculus). Brachymetropia and hypermetropia are both, therefore, referable to ametropia.

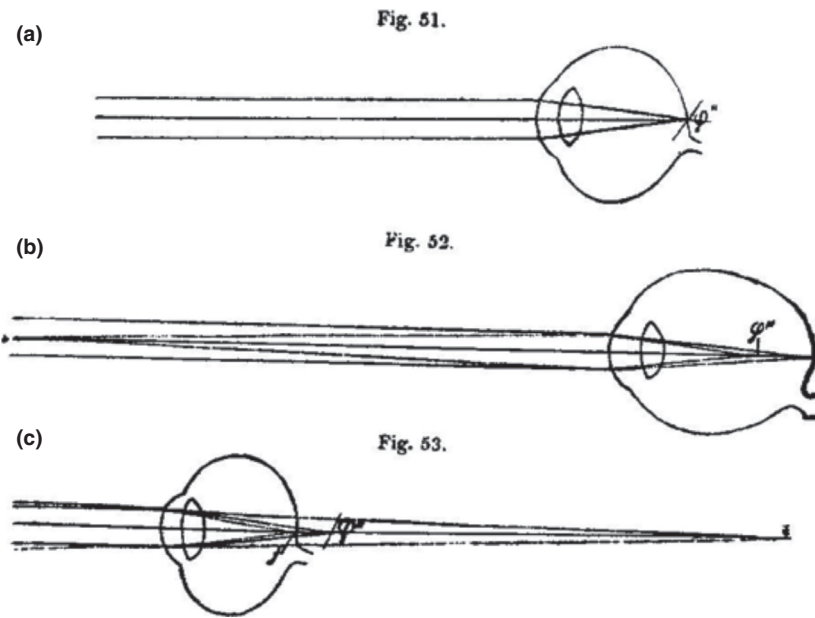
Brachymetropia is evidently nothing else than myopia, and it appears preferable to use the word myopia, as being an established term. The word brachymetropia was formed only in contrast to hypermetropia, to which expression I thought it right to adhere.

Hence it is evident that myopia and hypermetropia are opposite conditions. That myopia is of very frequent occurrence, and is to be considered as an important condition, has long been admitted. Still more common, however, and more important in its results is hypermetropia, which has hitherto been for the most part either overlooked, or confounded with other states.

Note that Donders' definitions, i.e. his 'measures' of the eye, relate to the positions of the second focal point of the eye with respect to the retina. The focal length of the eye is relatively too short in myopia and too long in hypermetropia. It is of interest that his figures of the different eyes (reproduced here as Figure 2) show the axial length of the myopic eye as being relatively too long and that of the hypermetropic eye as being relatively too short. He is, however, careful to make the important point that emmetropic eyes (and by implication ametropic eyes) can have many different geometries.

The importance of Donders' clear distinction between the various types of spherical refractive error soon received wide recognition. For example, a few years later in 1868 Charles Darwin<sup>8</sup> writes, when discussing hereditary conditions which affect the eye:

With respect to the eye itself, the highest authority in England, Mr. Bowman, has been so kind as to give me



**Figure 2.** Donders<sup>3</sup> illustrations of (a) emmetropic, (b) myopic and (c) hyperopic eyes and their far points. The figure numbers are the originals.

the following remarks on certain inherited imperfections. First, hypermetropia, or morbidly long sight: in this affection, the organ, instead of being spherical, is too flat from front to back, and is often altogether too small, so that the retina is brought too forward for the focus of the humours; consequently a convex glass is required for clear vision of near objects, and frequently even of distant ones. This state occurs congenitally, or at a very early age, often in several children of the same family, where one of the parents has presented it. Secondly, myopia, or short-sight, in which the eye is egg-shaped, and too long from front to back; the retina in this case lies behind the focus, and is therefore fitted to see distinctly only very near objects. This condition is not commonly congenital, but comes on in youth, the liability to it being well known to be transmissible from parent to child. The change from the spherical to the ovoidal shape seems the immediate consequence of something like inflammation of the coats, under which they yield, and there is ground for believing that it may often originate in causes acting directly on the individual affected, and may thenceforward become transmissible. When both parents are myopic Mr. Bowman has observed the hereditary tendency in this direction to be heightened, and some of the children to be myopic at an earlier age or in a higher degree than their parents.

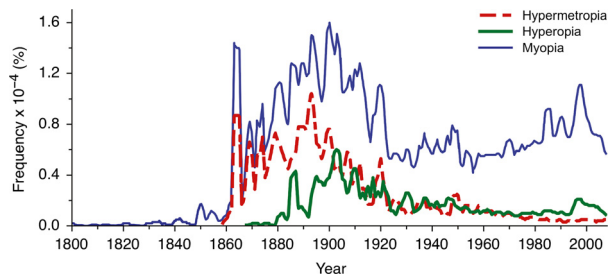
According to Donders<sup>3</sup>, after he had presented his own work at a meeting in Heidelberg in 1859, Helmholtz who had

heard the lecture quickly suggested the use of the alternative term hyperopia but by 1867 Helmholtz appears to have been persuaded to use Donders' terminology and writes:

*'Augen, die im Gegentheil nicht nur parallele, sondern auch convergirend einfallende Strahlen vereinigen können, heissen hypermetropische'* [On the other hand, eyes that can unite not only parallel, but also convergent incident rays, are called hypermetropic, translated slightly differently in Helmholtz<sup>10</sup>, p.137, as 'on the other hand, an eye which can focus on the retina not simply parallel but even convergent rays is said to be hypermetropic' – Helmholtz is obviously thinking of an eye which can accommodate].

Nevertheless in spite of Helmholtz's acceptance of hypermetropia, others continued to prefer 'hyperopia'.

In fact, in subsequent years there has been no unanimity as to which term is preferable. For example, in the English translation of Landolt's textbook 'The Refraction and Accommodation of the Eye'<sup>11</sup> we find that although the initial relevant section heading is 'Hypermetropia or Hyperopia', throughout the text that follows hyperopia is generally, but not always, preferred (e.g. pp 132–142, 347–381, 411–413).<sup>11</sup> Tscherning uses the term 'hypermetropie' in the French original of his well-known book 'Physiologic Optics'<sup>12</sup> and hypermetropia is also used in the later revised and enlarged English edition of the work.<sup>13</sup> In 1902 the translator of 'Diseases of the Eye and Ophthalmoscopy' by contact lens pioneer Adolf Eugen Fick compromised by using hypermetropia in one section of the text and



**Figure 3.** Frequency of occurrence of the words myopia, hypermetropia and hyperopia and as a function of year of publication for books in the English language. The plots show 3-year running averages of the raw n-gram data.

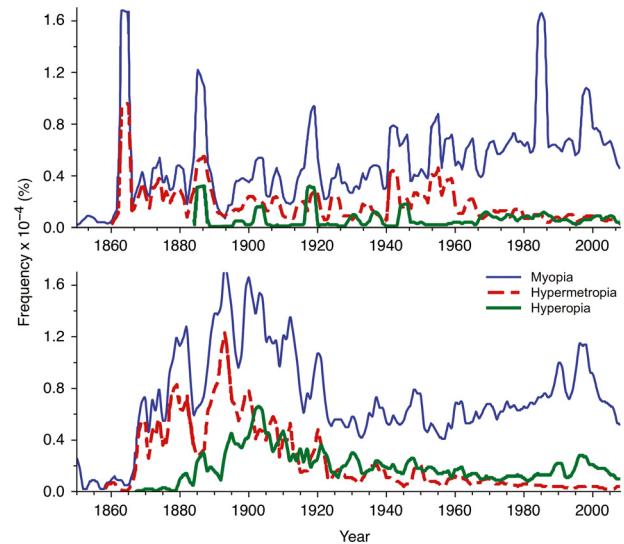
hyperopia in another (Fick<sup>14</sup>, pp 37–41 and 363–367). Southall in 1937 preferred the use of hyperopia, which he described as ‘a shorter and more convenient term’ than hypermetropia.<sup>15</sup>

Although the authors or editors of some more modern textbooks standardise on hyperopia,<sup>16–21</sup> other authors still prefer hypermetropia.<sup>1,22,23</sup> Duke-Elder<sup>24</sup> remarks acridly ‘...hyperopia: although shorter the word is not etymologically so good as that (hypermetropia) introduced by Donders’. His reservations presumably arise in part because hyperopia could be interpreted to mean that the eye itself was too long, rather than its ‘measure’ – the focal length.

Some further insights into the usage of the two terms can be gained using the methods recently introduced by Leffler *et al.*<sup>25</sup> to examine the evolution and impact of eye and vision terms over the last two centuries. The approach involves determining the frequency of occurrence of the chosen terms in a large sample of the books published each year. ‘Frequency’ here is the number of times that the term appeared in a given year, divided by the total number of words in all the books examined in that year. An approximation to these frequencies can be obtained from the Google n-gram database, which is derived from around 4% of the books ever published.<sup>26,27</sup> Although these data must be viewed with some caution, since the representative nature of the book sample is not guaranteed and words like myopia or myopic may sometimes be used in a figurative, rather than a technical, sense, the general trends are likely to be broadly valid.

Figure 3 shows the plot for current spherical ametropia terms as found in all literature in the English language. Before the late 1850s myopia was only occasionally used, probably because it was more commonly called ‘shortsight’. There was an abrupt increase in usage of both myopia and hypermetropia around 1860, presumably catalysed by Donders’ work. Like Donders himself, most writers never made use of the term brachymetropia.

It can be seen that usage of the term hyperopia as an alternative to hypermetropia started to grow after about



**Figure 4.** Frequency of occurrence of the words myopia, hypermetropia and hyperopia as a function of year of publication for books predominantly in the English language that were published in (top) Great Britain and (bottom) the United States. The frequencies are 3-year running averages of the raw data.

1880 and from about 1900 to 1970 the frequencies of usage of the two terms appear to be similar. However, a trend for hyperopia to be used more frequently has emerged over the last few decades. This is mainly due to material in American, rather than British, English (Figure 4). In European languages it appears that hypermetropia, or terms derived from it (hypermétropie, hipermetropia, ipermetropia etc.), remains dominant.

In general, it appears that both words, each coined by a giant in the field, continue to have wide and equally valid currency and that both are well understood within the ophthalmic community. Donders was sufficiently a realist to accept the continuing usage of myopia, rather than his ‘brachymetropia’, and we may equally accept hyperopia, in spite of Duke-Elder’s etymological criticisms. As Lewis Carroll’s Humpty Dumpty remarked, ‘When I use a word, it means just what I choose it to mean – neither more nor less’.<sup>28</sup> Since there is no ambiguity in the case under discussion, it would seem reasonable for both terms to remain in use.

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