On the Evolution of Binocular Ophthalmoscopy

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The need for stereopsis arose soon after the discovery of the ophthalmoscope, not least because the glaucomatous cup was mistaken for a swelling. At that time, Brewster's popular stereoscope was already in use, and its theory and method were then applied to ophthalmoscopy by Giraud-Teulon. His was the first binocular instrument, subsequently much improved by Zachariah Laurence. Binocular indirect ophthalmoscopy was abandoned toward the end of the 19th century in favor of direct monocular ophthalmoscopy, until it was revived in the 1950s by Schepens.

Granted that the history of ophthalmoscopy has already been well covered, a short supplemental note on the early evolution of the binocular method may perhaps be timely in remembrance of Charles Schepens, who died March 28, 2006. His invention and advocacy of modern indirect binocular ophthalmoscopy in the service of improved ocular diagnosis and surgery are well known.1 The lives he thereby saved or improved were in addition to those he saved while in the resistance in France during World War II.2 But, as is often the case with innovators, at first his ideas and projects were said to have received less than enthusiastic welcome in conservative Boston, Mass, where most of the endeavor was in the fields of pathology and clinical science rather than optical instrumentation and complex retinal surgery.3 Happily, he prevailed.

The desire for binocularity and stereopsis arose soon after the celebrated invention of the ophthalmoscope in 1851. As John Zachariah Laurence (1830-1874), FRCS, of London put it in 1866:4

The details of the fundus oculi, when viewed by means of monocular ophthalmoscopes, appear to be all in the same plane. The depression of the cupped optic disc, or the elevation of the retina by a sub-retinal effusion, would be rather inferred from the bending of vessels, by the changing of focus necessary for the clear definition of each part, by alteration in color, illumination &c, than from any appearance of actual relief.

This deficiency resulted in the embarrassingly mistaken description, in print and pictures, of the glaucomatous cup as a protuberance, a swelling of the optic nerve head.5,6 As a remedy, the idea then arose to place 1 ophthalmoscope before each eye,7 or mount the 2 ophthalmoscopes on a horizontal rod. It did not work, mainly because it could not be used at the close distance needed for the direct view, and the indirect image was too dim and not really stereoscopic:

The problem appeared then solved by having a larger mirror than usual, pierced with two eye-holes at a distance equal to that of the pupils of the eyes. I had such a mirror actually constructed; and went so far as to publish an account of it in the Medical Times and Gazette; but soon had reason to regret this publication, by finding my instrument was really not a binocular one.8

Earlier, in 1843, Sir David Brewster published a description of a prismatic stereoscope, and in 1856, further elaborated on its various forms in his groundbreaking book "The Stereoscope, Its History, Theory and Construction, With Its Application to the Fine and Useful Arts and to Education."9 In it he described Charles Wheatstone's original invention of the reflecting stereoscope10 and...
detailed the construction of his own lenticular one, which was small, practical, and much improved (Figure 1). (From the ophthalmologic point of view it is of interest to note that Brewster was the first to discover, in 1843, that the sensation of “floaters” was the result of vitreous opacities.) By that time a large variety of photographic pictures for his device came to market, and Brewster's stereoscope emerged as a common household entertainment vehicle, akin perhaps to television today.

Five years after Brewster's publication, the subject of binocularity and stereopsis was applied specifically to ophthalmology by Marc-Antoine-Louis Felix Giraud-Teulon (1816-1887), whose first name, incidentally, was not Marc as is occasionally given but was Felix (his publications only gave the initial letter F). The full title of his book may be translated as “Physiology and Functional Pathology of Binocular Vision, With Insight into Its Adaptation to All Optical Instruments for Vision With Both Eyes, to Ophthalmoscopy and Stereoscopy.” The same year (1861) he also introduced his invention of a binocular stereoscopic ophthalmoscope, which has since been described, diagrammed, and shown in color photographs in many historical sources.

In 1866, Henry Williams of Boston enthusiastically endorsed it:

In order to obtain the advantage of vision with both eyes, a most ingenious instrument has been devised, which, by combination of rhombohedral and prismatic glasses behind the mirror...as in the stereoscope, objects may be seen in apparent relief...But it has the disadvantage of being somewhat less quickly adapted to the eye under observation than the small ophthalmoscope of Liebreich.

All the good intentions and theories notwithstanding, Giraud-Teulon's ophthalmoscope had other serious drawbacks. In the original model the interpupillary distance between the oculars was fixed, so that it fitted only a standard observer in 1 state of convergence. The problem was corrected in the later models, which are usually cited and pictured in the literature, by the addition of a screw that moved the reflecting rhomboids or prisms to the desired pupillary distance. Convergence was eased by the introduction of prisms between the oculars and the observer's eyes. Nevertheless, the instrument's position on the horizontal axis made it hard to rotate on the sagittal or vertical axes for peripheral views of the fundus, and when done by head tilt or rotation, the light was displaced off the mirror. Finally, the necessity to interpose several corrective lenses between the observer and patient for a direct view was very cumbersome.
Several improvements were incorporated in the binocular ophthalmoscope invented the following year by John Zachariah Laurence. Laurence founded the Ophthalmic Hospital Southwark in 1857, a minor competitor of Moorfields, and the first Ophthalmic Review journal in 1864 (others with the same title followed), of which only 3 volumes were published. Along with many other practitioners of the time, he also invented a monocular ophthalmoscope in addition to the binocular one described below:

My friend, Dr. Giraud-Teulon of Paris, has devised an ophthalmoscope which obviates this objection [dim image]. I have recently simplified this instrument by substituting for the rhombs ordinary reflectors of quicksilvered glass or speculum-metal. The simple proper inclination of the reflectors R'R' suffices (on the principle of Wheatstone's reflecting stereoscope) to effect the coalescence of the double images without any additional prisms. This form of instrument admits of adjustment of the eye-mirrors (R'R') to suit both the different separation of the eyes met with in different individuals, as also any deviation of accommodation. This instrument was manufactured by Messrs. Murray and Heath, of 43, Piccadilly.

This second binocular ophthalmoscope (Figure 2) was, according to contemporary practitioners, much better than the first: "[It] affords means of examining the fundus oculi with a facility and accuracy never before obtained." A case of retinal detachment, easily detected with this new binocular ophthalmoscope, was also then published. However, it still had some deficiencies:

An instrument of this kind was manufactured under the superintendence of Mr. Heisch, of the firm of Murray and Heath, Piccadilly, and succeeded admirably in practice. It was found, however, that the mirrors, if made of metal, would be liable to tarnish, and difficult to clean; and if made of silvered glass, they produced confusion by reflecting from two surfaces. Eventually it was necessary to substitute prisms for the mirrors [R'R'], and by the joint labors of Mr. Laurence and Mr. Heisch the instrument has been brought to very great excellence.

This improved second instrument is cited and pictured in the later literature. Despite the enthusiastic endorsements, Laurence's indirect stereoscopic ophthalmoscope could not solve some inherent methodologic problems. First, it used dim light from an oil lamp, or later gas lamp, reflected from the instrument's mirror, in contrast to the later invented electric light source that moved with the ophthalmoscope. Second, it required the use of both hands, one to hold the instrument, the other for the condensing lens (Figure 3), thus preventing use of the second hand for fundus drawing or scleral depression. With improvements in the 1-handed direct ophthalmoscope, mainly by its electric light source and incorporated corrective lenses, the indirect binocular view seemed to offer no practical advantages, at a time furthermore when peripheral fundus disorders such as retinal detachments or tumors were incurable anyway.

Julius Hirschberg, responding in his German patriotic manner to the pride of the French in their original invention, asked in 1918: "What was discovered with this [Giraud-Teulon's instrument] that was not previously known?" A judgment from the United States in 1913 was similar: "Binocular ophthalmoscopes are not generally used, and it is a question whether on the whole they really possess any advantage over the ordinary instrument." The epochal invention of modern retinal detachment surgery by Jules Gonin in the early 1920s used monocular indirect ophthalmoscopes, then commonly used in Europe. Thus again, up to the 1950s:

Hughes: What was Lancaster's opinion of indirect ophthalmoscopy?
Boeder: No opinion. He didn't use it.
Hughes: Well, that was true of quite a number of the old guard, wasn't it? Didn't they feel that they were doing well enough with direct ophthalmoscopy?
Boeder: Precisely. Precisely.

Today, Schepens-type indirect binocular ophthalmoscopes are near every ophthalmic examining chair in the world, facilitating advances in the surgical methods he initiated. A historical perspective allows us to reflect and appreciate the obstacles he and his predecessors had to overcome, and thereby learn to better value their achievements and their contributions to making our glass half full.

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REFERENCES

Archives Web Quiz Winner

Congratulations to the winner of our January quiz, Christos Christakopoulos, MD, Department of Ophthalmology, Eye Clinic of Aalborg Hospital, Aarhus University, Denmark. The correct answer to our January challenge was acute exudative polymorphous vitelliform maculopathy. For a complete discussion of this case, see the Clinicopathologic Reports, Case Reports, and Small Case Series section in the February Archives (Vaclavik V, Ooi KGJ, Bird AC, Robson AG, Holder GE, Webster AR. Autofluorescence findings in acute exudative polymorphous vitelliform maculopathy. Arch Ophthalmol. 2007;125:274-277).

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