

Historical Perspective**Benjamin Esterman (1906–1994) and the binocular visual field scoring grid that became a world standard for assessing driver eligibility**Tomas Bro 

Department of Ophthalmology Eksjö, Region Jönköping County and Section for Ophthalmology, Department of Clinical Sciences, Lund University, Lund, Sweden

**ABSTRACT.** The visual field grid developed by the ophthalmologist Benjamin Esterman (1906–1994) is today an accepted standard for assessing driver eligibility in many parts of the world. However, little is published about the scientific process that led to the test or about the person who developed it. The aim of this article is to portray the ophthalmologist Benjamin Esterman, and to discuss the visual field grid with his name and its current role in assessing driving eligibility.

**Key words:** Benjamin Esterman – visual field – visual field scoring – driving ability

Acta Ophthalmol. 2022; 100: 828–833

© 2022 The Author. Acta Ophthalmologica published by John Wiley & Sons Ltd on behalf of Acta Ophthalmologica Scandinavica Foundation.

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDeriv License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

doi: 10.1111/aos.15096

Benjamin Esterman was born the 1st of May 1906 in a Jewish family in Vilnius, which at that time belonged to the Russian empire (Esterman 2017). In 1908, when he was still a toddler, his family immigrated to the USA. This was not an unusual journey; almost 25% of the population of current Lithuania emigrated between 1868 and 1914. The emigration was especially high around 1905, after a wave of pogroms against Jews followed by the Russian-Japanese war and the first Russian revolution (Balkelis 2010). Esterman grew up in Brooklyn, New York and married Sophie Milgram (1905–1968) in 1935. Their honeymoon trip was to Europe. During the journey, they visited Germany in order to assess where Nazism was heading. They collected over 50 items, such as badges and postcards, that today can

be seen at the Holocaust Memorial Museum in New York (United States Holocaust Memorial Museum 1996). Benjamin and Sophie had three children: one daughter and two sons. Sophie Esterman died of cancer in 1968 and, four years later, Benjamin married Cinnabelle Morris (1912–1995), and became stepfather to her adult son (Lawrence 1972).

Benjamin Esterman's clinical career was initiated when he graduated from Columbia College and Cornell University Medical School in 1927. He completed his specialist training at the New York Post-Graduate Hospital and Knapp Memorial Hospital. At the latter institution, he was the cofounder in 1935 of one of the earliest separate clinics for glaucoma (Schlossman 2003). At the same time, he became one of the first physicians to

describe a method of keeping glaucoma records. From the emphasis on pain, nausea, and blurred vision in these charts, one can conclude that his clinic mostly dealt with angle closure glaucoma. The treatment available was iridectomy and myotics (Schoenberg & Esterman 1937) (Fig. 1). One reason for his interest in glaucoma could be that his mother had the disease, experiencing a shrinking visual field during the years that Esterman was at college and university (Esterman 1992). For more than 40 years, he was associated with Manhattan Eye, Ear and Throat Hospital, where he worked as an eye surgeon and also trained many young ophthalmologists (Saxon 1994).

Benjamin Esterman's earlier scientific works include both case studies and reviews in the field of glaucoma, oncology, and paediatric ophthalmology. (Esterman 1947a, 1947b; Esterman et al. 1947; Esterman 1948).

He also obtained a patent for a device to ease the positioning of a current tonometer (Esterman 1955). During the 1960s he was interested in medical consequences from the noise of jet airplanes, and founded an organization with the purpose of minimizing the noise from the airport later named John F. Kennedy International Airport (Drake 1962). He also wrote a well reviewed book for patients about ocular diseases and eye care. Interestingly enough, the glaucoma chapter begins with a case report about glaucoma as an underlying cause of severe traffic accidents (Esterman 1977).

### GLAUCOMA RECORD - EYE HISTORY I

CLINIC NO. 209412

A. NAME **a R** AGE 51 SEX F M  S  SER. DES. CLINIC **Kuaff** SERIAL NO.

ADDRESS 642 a Ave, Bx. OCCUP. Chambermaid RACE Wh SERVICE OF Dr. Kuaff DATE OF HISTORY Nov. 12, 1935

B. DIAGNOSES  
 1. EYE { PRINCIPAL o.d. Chr. Simple Glaucoma  
 o.s. Anophthalmos  
 SECONDARY o.d. Hyp. Astig., Presby.  
 o.s. }  
 2. GENERAL Hypert thyroidism, Sec. Anemia

C. OPERATIONS AND DATES  
 o.d. —  
 o.s. Stridectomy (?) 1930  
 Enucleation 1930

D. CHIEF COMPLAINT  
 o.d. Vision poor, 4 mo. Headaches and foggy vision for past year.

E. GLAUCOMA SYMPTOMS	SEVERITY 1+ TO 4+		DATE OF ONSET		BROUGHT ON BY SEE E		RELIEVED BY SEE G		1 <sup>ST</sup> ACUTE ATTACK		LAST ATTACK	
	R	L	R	L	INDICATE BY #	INDICATE BY #	DATE 1930	DURATION HRS	DATE	DURATION HRS	R or L	R or L
FAILING VISION	2+	4+	7/35	'30	1, 4, 6	22, 26			4+			
FOGGING OF VISION	1+	1+	11/34	'28	1, 4, 6	22, 26						
PAIN - OCULAR		4+		'30					4+			
- SUPRAORBITAL	1+		11/34									
- HEADACHE		4+		'30					4+			
HALOS (RAINBOW)	1+	1+	11/34	'28	1, 4, 6	22, 26						
REDNESS												
NAUSEA, VOMITING		2+		'30					2+			
CONSCIOUS OF FIELD LOSS	3+		7/35									
WEAK ACCOMMODATION												

USE REVERSE, FOR ADDITIONAL DATA AND DETAILS

F. SYMPTOMS BROUGHT ON BY	G. SYMPTOMS RELIEVED BY	H. GLAUCOMA DISCOVERED
1. TIME OF DAY	21. SLEEP	DATE 1930
2. FATIGUE	22. REST	BY WHOM other clinic
3. USE OF EYES	23. SEDATIVE	ADVISED: drops o.d. operation o.s.
4. WORRY	24. EYE DROPS	DATE SEEN BEFORE GLAUCOMA DISCOVERED 1928, 1929
5. TROUBLE AT HOME	25. COLD APPLIC.	BY WHOM of tonetr.
6. HEAD COLD	26. HOT APPLIC.	DROPS STARTED (DATE) R: 1930 (over) L: —
7. ILLNESS	27. CHANGE OF ENVIRONMENT	AT PRESENT USING MO DROPS FREQUENCY R: L:
8. CONSTIP. OR DIGESTIVE UPSET	28. HOSPITALIZED	TOTAL # ACUTE ATTACKS: R: 0 L: 1
9. MENSES	29. OPERATION	
10. WEATHER	30. SPONTANEOUS	
11. NO KNOWN CASE	31.	
12.	32. Enucleation	
13.	33.	

SIGNATURE **B.E. M.D.**

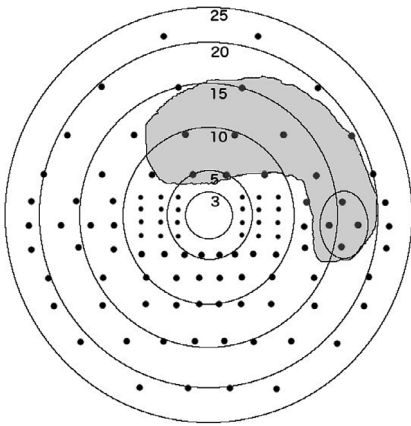
### GLAUCOMA - SUBSEQUENT RECORD IV

CLINIC NO. 209412

NAME **a R** SERIAL NO.

30 DATE	31. VISION WITH BEST CORR.		32. MEDICATION				33. HOURS SINCE LAST MED.		34. TENSION mm.		35.	36. Rx	37. REMARKS	38. CLINICIAN	39. PROBITY
	R	L	R MED. FREQ.	L MED. FREQ.	R	L	R	L	R	L					
11-19-35	20/40	-	#6 4xd	"	4	-	28	-			#6 5xd	No fogging or halos	E	E	
11-26	20/40+2	-	#5 5xd	-	4	-	23	-			"	Basal metab.: +15	E		
12-3	20/40+2	-	#6 5xd	-	4	-	23				"	Rx: her new gl.	E		
12-10	20/40+2	-	"	-	4		23				"		E		
12-17	20/40-3		"		4		23				(buffered)	Redness & tearing 2d. Conjunctivitis better since using buffered #6	E		
12-31	20/40+1		(buffered)		3		21				"		E	B	
1936 1-14	20/40+3		"		3 1/2		21				"		E		
1-28	20/70+2		"		20!		36!				"	Ran out of drops	E		
2-11	20/40		"		3 1/2		21				"		E	B	
2-25	20/40+2		"		4		23				"		E		
3-17	20/50-2		"		4		30				#6 q 2 h. Bromides	Trouble at home (see over)	E		
3-24	20/40-1		#6 q 2 h. Bromides		4		23				"		E		
4-7	20/40		"		4		23				"		E	B	
4-28	20/40+1		"		3 1/2		20				#6 4xd. Disc. Bromides	New living quarters	E		
5-19	20/40		#6 4xd		4		20				"	Better	E		

Fig. 1. Background history and subsequent glaucoma record described by Schoenberg and Esterman in 1937.



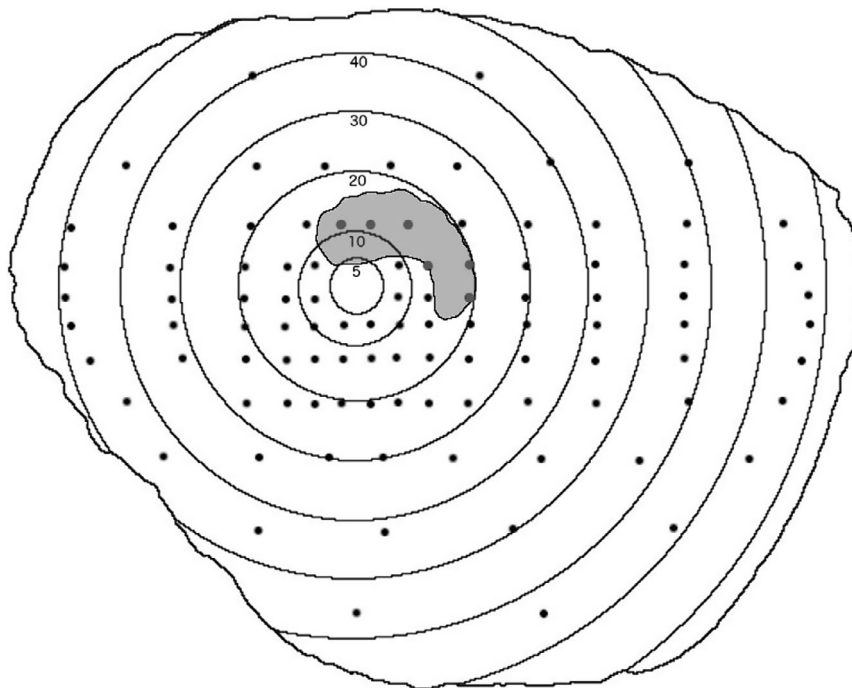
**Fig. 2.** The first of Esterman’s grids, presented in 1967, was based on a monocular tangent screen examination. A visual field defect is quantified by the number of points it includes. Points touching the border are also within the defect. In this example, the scotoma includes 14 dots, whereof four are within the normal blind spot in the right eye, resulting in an Esterman score of  $(100-10)/100=90\%$ .

In 1967, at the age of 61, Esterman presented his first visual field system to quantify visual field function. A transparent sheet with a grid with 104 dots, of which four were eliminated by normal blind spot in either eye, was put above the result from a tangent screen examination. The importance of the

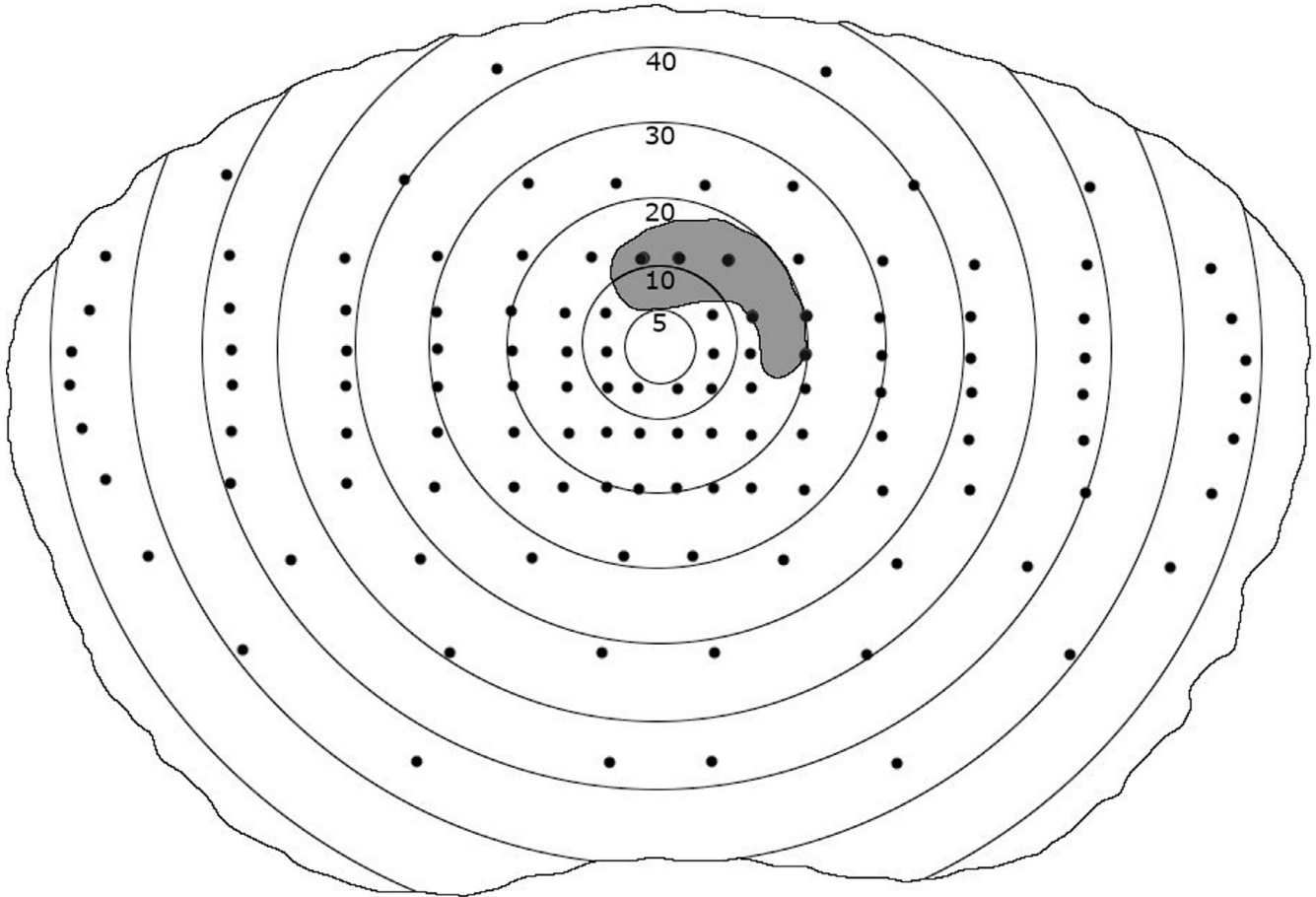
visual field was assumed to be greatest near the center, in the lower visual field and along the horizontal meridian. Therefore, the grid was made tighter in these areas. The inferior field contained twice as many test points as the superior. By counting the dots unaffected by scotomas, the remaining visual field could be expressed as a percentage. No dots were placed within the central 3° radius, leaving this area to be expressed by a Snellen score (Fig. 1) (Esterman 1967). In the second version, he constructed a similar but larger grid to be used with the result from a Goldmann examination (Fig. 2). The radius was 50° nasally and 80° temporally. No dots were placed within the central 5° (Esterman 1968). When he was 76 years old, Esterman presented the third and final version of the grid, a binocular version containing a total of 120 test points (Esterman 1982). The two previous monocular grids were now merged to be used with the result from a binocular Goldmann examination (Fig. 3). Blind areas in one eye could therefore be compensated by the vision in the other. The three grids are incompatible, meaning that the same scotoma gives a different score for each method (Figs 2–4).

In 1984, the American Medical Association adopted the binocular Esterman disability score (EDS) as a standard for evaluating visual impairment. It became therefore used in worker’s compensation systems both in the USA and internationally (American Medical Association 1984). In the mid-1980s, the grid was also incorporated into the new computerized perimeters. With this method, dots were no longer counted from a result of manual kinetic perimetric examination. Instead, the perimeter presented light stimulus in the same pattern as the old binocular grid. This transition required an adjustment of the test objects, where a light intensity of 2,500 apostilbs (asb) was considered to be most equivalent to the previously-accepted standard of the Goldmann III 4e stimulus (Esterman et al. 1985).

Today, the Esterman test is included in several automated perimeters. Internet searches in September 2021 with the terms “Esterman” and “perimeter” identified ten instruments from eight manufacturers (Elektron eye technology 2021; Kowa 2011; Rodenstock 2012; Carl Zeiss Meditec 2018; Optopol 2019; Haag-Streit Diagnostics 2020; Oculus 2021; Visuscience 2021). Additional information of the tests was obtained from



**Fig. 3.** The second of Esterman’s monocular grids, presented in 1968, was based on a monocular Goldman perimetry. The number of points is still 100 but the radius is 50° nasal and 80° temporal. There are no points within the central 5° radius. The same scotoma as in Figure 2 therefore includes six points, resulting in an Esterman score of  $(100-6)/100 = 94\%$ .



**Fig. 4.** In the third and final version of the scoring system presented in 1982, two monocular grids were merged into one binocular, to contain 120 test points in total. If the same scotoma from Figures 2 and 3 (unlikely) occur in both eyes the score is  $(120-6)/120 = 95\%$ .

**Table 1.** Technical specifications of binocular Esterman programs in different automated perimeters

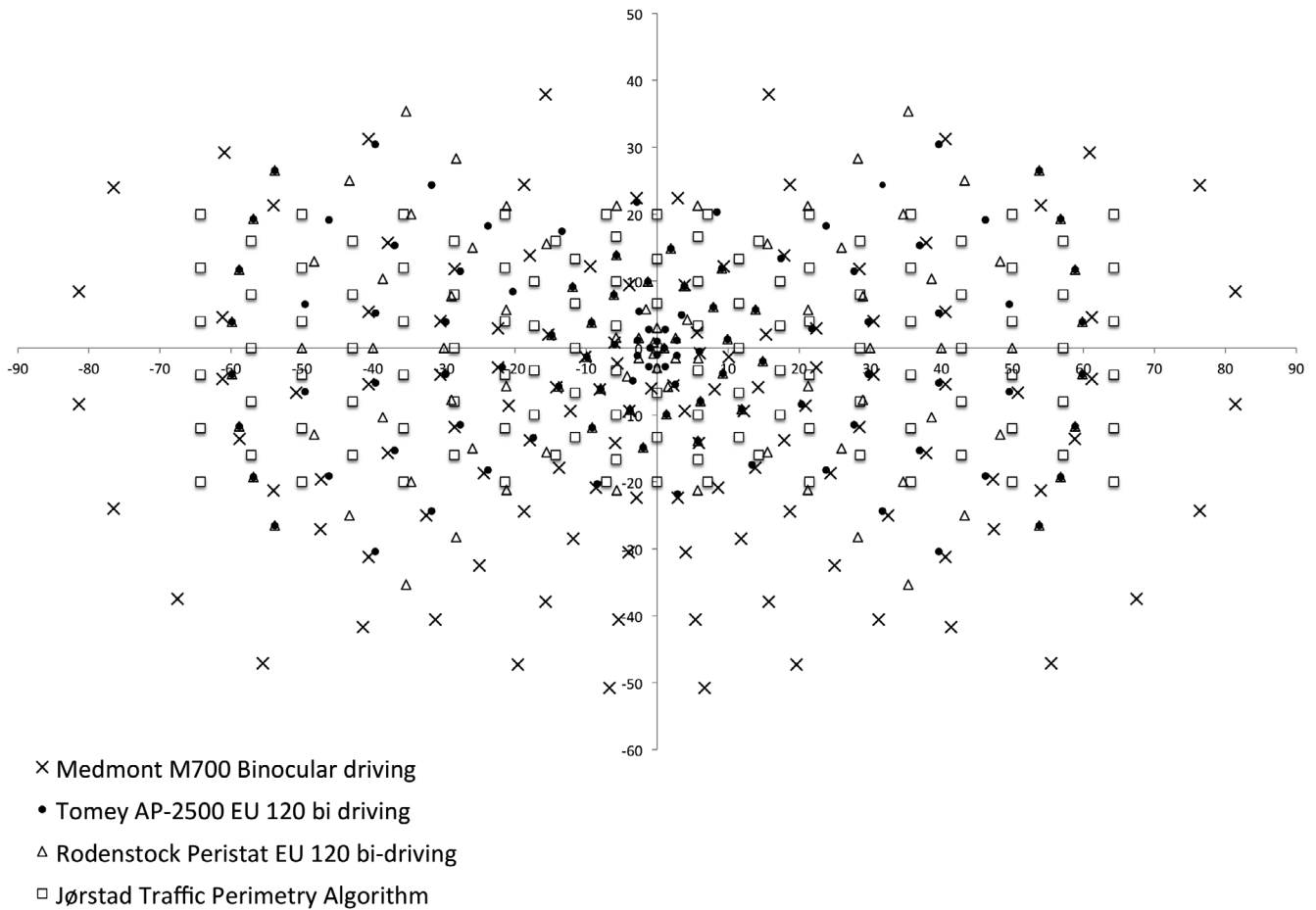
Company	Product	Intensity (asb)	Duration (ms)	Points within 120 × 40	Points within 20 degrees	Points within 10 degrees	Most central point	Fixation control
Carl Zeiss	HFA3	1000	500	64	24	7	8.5	No
Haag Streit	Octopus 900	1000	500	64	24	7	7.6	Yes
Kowa	Automatic Perimeter	1000	400	66	24	7	8.5	No
Oculus	Twinfield 2	1000	200	72	28	7	7.9	No?
Optopol	PTS	1000	250	64	22	9	9.5	No
Topcon	Henson 9000	1000	200	74	26	7	9.5	No
Visuscience	IFA 900/950/960	2500	200	64	24	8	8.5	Yes
Rodenstock	Perimat	1000	400	72	24	7	7.6	No

the manufacturers. The compilation revealed that the current standard for the stimulus intensity is not the previously-validated 2,500 asb, but 1,000 asb (10 dB if the maximum stimulus intensity is 10,000 asb). This makes the test somewhat stricter than the original version. However, a recent study has shown that the Esterman score in Humphrey perimeter HFA3 correlates well with the manual calculated score from a Goldmann examination for most diseases (Yanagisawa et al. 2018). Esterman never defined the duration of the stimulus, and in

current perimeters this value varies from 200 to 500 milliseconds between different manufacturers. The positions of the test points were further only defined graphically in the old manuscripts, without exact coordinates. As a consequence, the number of test points within the 120° × 40° varies between 64 and 74 points and within the central 20° between 22 and 28 points. The location of the most central test point differs from a radius of 7.6° to 9.5° (Table 1). Even if these differences probably have no clinical relevance, they may have severe consequences when the test

is used to fulfil legal visual requirements for driving.

The Esterman test has many advantages. It was the first way to quantify binocular visual field loss, it is relatively easy to perform, and today it is available in most perimeters. However, the use of the Esterman test has also been questioned, both in assessing how visual field impairment affects activities of daily living and in driving issues. In the fifth edition of the AMA guides from 2001, the system



**Fig. 5.** Four bilateral perimetric algorithms developed to assess visual field crucial for driving.

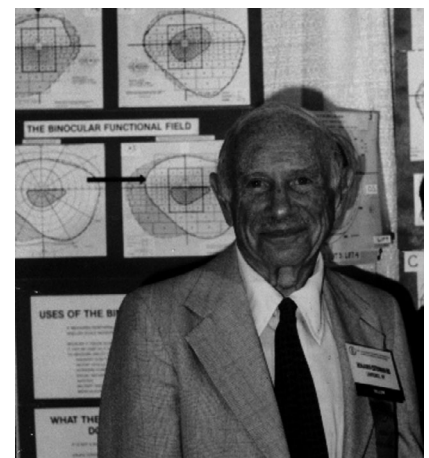
was abandoned and replaced by a grid called Visual Field Score (VFS). Like the Esterman grid, this system has more points in the inferior than in the superior field but, in addition, it also emphasises the central field by having half of of the test points within 10° from fixation (American Medical Association. 2001). Considering driving, in 2005 a European expert panel advised against the use of Esterman perimetry to assess driver eligibility. This position was motivated by the fact that the test was never developed for this purpose and that no central test points are presented. The lack of standardization of test point positions in Esterman programs, and variations in stimulus duration and fixation control also make it hard to perform fully equivalent tests. Instead, the group recommended the development of a specific traffic perimetry algorithm, with more test points in the central area (The Eyesight Working Group 2005). The importance of central visual field for driving has also

been confirmed by later research. However, as compensation abilities vary widely between individuals, a practical driving assessment still remains the only way to fully understand the impact of visual impairment on a given person’s driving ability (Patterson et al. 2019).

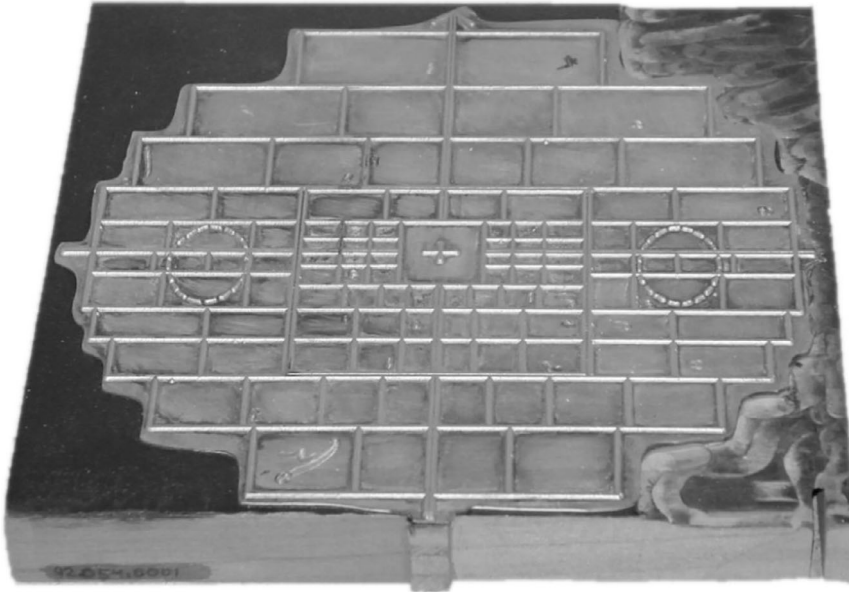
Several other traffic perimetry algorithms have been proposed with more central test points; most recently, a traffic perimetry algorithm based on the recommendations from the European Eyesight Working Group (Jorstad et al. 2021) (Fig. 5). However, no such system has yet been globally recognised. Thus, the Esterman test remains the accepted standard for driving in several countries. The test results needed to fulfil the requirements for drivers’ licensing vary between different countries. For example, a loss up to three adjoining points within the central 20 degrees radius is allowed in the UK and Australia (Austrroads Ltd 2017; Driver and Vehicle Licensing Agency 2021), while only one missed

point in this area is allowed in Norway (Helsedirektoratet 2017).

In summery, the grid developed by Benjamin Esterman was the first described method to quantify peripheral binocular visual field loss (Figs 6 and 7). Even if the initial idea was to score the



**Fig. 6.** Benjamin Esterman presenting his works at the American Academy of Ophthalmology meeting in Dallas 1987.



**Fig. 7.** The first of Benjamin Esterman's visual field grids can be seen on a metal printing plate mounted on wood at the Truhlsen-Marmor Museum of the Eye in San Francisco, California (Catalog Number 1992.054.00001).

visual field, the Esterman grid is today a standard for driving issues in many parts of the world. As such, it forms a stable base for the development of future improved systems, which hopefully can more precisely measure aspects of the visual field crucial for driving.

**Acknowledgements**

Thanks to Daniel Esterman for providing information and private photographs and to Anders Heijl and Bertil Lindblom for valuable comments.

**References**

American Medical Association (1984): The visual system. In: Guides to the Evaluation of Permanent Impairment, 2nd edn. Chicago: American Medical Association. Available at: [https://www.worldcat.org/title/guides-to-the-evaluation-of-permanent-impairment/oclc/978227256&referer=brief\\_results](https://www.worldcat.org/title/guides-to-the-evaluation-of-permanent-impairment/oclc/978227256&referer=brief_results)

American Medical Association (2001): Guides to the evaluation of permanent impairment, 5th edn. Chicago: American Medical Association.

Austrroads Ltd (2017): Assessing Fitness to Drive 2016 as amended up to August 2017.

Balkelis T (2010): Opening Gates to the West: Lithuanian and Jewish Migrations from the Lithuanian Provinces, 1867-1914. *Ethnicity studies (Etniškumo studijos)* **42**: 55.

Carl Zeiss Meditec (2018): Humphrey® Field Analyzer 3 (HFA3) Instructions for Use – Models 830, 840, 850, 860. Available at: [https://www.zeiss.fr/content/dam/Meditec/international/ifu/documents/hfa3/current/2660021166131\\_a\\_artwork.pdf](https://www.zeiss.fr/content/dam/Meditec/international/ifu/documents/hfa3/current/2660021166131_a_artwork.pdf). (Accessed on 12 Aug 2021).

Drake D (1962): What about the Noise of the Splashes? *Newsday* 1962-10-30. Nassau Ed. New York: Hempstead p. 26.

Driver and Vehicle Licensing Agency (2021): Advice for medical professionals to follow when assessing drivers with visual disorders. Available at: <https://www.gov.uk/guidance/visual-disorders-assessing-fitness-to-drive#minimum-eyesight-standards-all-drivers>. (Accessed on 13 Aug 2021).

Elektron eye technology: 2021 Technical specifications Henson 7000 9000. Available at: <https://topconhealthcare.com/wp-content/uploads/2021/05/Henson-9000-Tech-Spec-Sheet-Rev0521-MCA4459.pdf>. (Accessed on 12 Aug 2021).

Esterman B (1947a): Choroideremia; report of a case. *Arch Ophthal* **37**: 716–721.

Esterman B (1947b): Some common ophthalmologic problems in pediatrics. *Med Clin North Am* **31**: 750–763.

Esterman B (1948): Headache as a symptom of chronic glaucoma. *Med Clin North Am* **32**: 839–844.

Esterman B (1955): US patent 2 708 847. In: United States Patent Office (ed.).

Esterman B (1967): Grid for scoring visual fields. I. Tangent screen. *Arch Ophthalmol* **77**: 780–786.

Esterman B (1968): Grid for scoring visual fields. II. Perimeter. *Arch Ophthalmol* **79**: 400–406.

Esterman B (1977): *The Eye Book A Specialist's Guide To Your Eyes And Their Care*. Great Ocean Pub: Arlington, Virginia.

Esterman B (1982): Functional scoring of the binocular field. *Ophthalmology* **89**: 1226–1234.

Esterman B (1992): Letter attached to artifact 1992.054.00001. Truhlsen - Marmor Museum of the Eye & The Stanley M. Truhlsen.

Esterman B, Blanche E, Wallach M & Bonelli A (1985): Computerized Scoring of the Functional Field Preliminary Report. In: *Documenta Ophthalmologica Proceedings Series*, vol **42**. Springer, Dordrecht. Available at: [https://doi.org/10.1007/978-94-009-5512-7\\_46](https://doi.org/10.1007/978-94-009-5512-7_46). In: Heijl A and Greve EL (eds.) Sixth International Visual Field Symposium. Springer, Dordrecht.

Esterman B, Laval J & Okrainetz C (1947): Intraepithelial epithelioma of the cornea and conjunctiva (Bowen's disease). *Am J Ophthalmol* **30**: 1537–1540.

Esterman D (2017): Benjamin Esterman. Available at: <https://www.geni.com/people/Benjamin-Esterman/600000066387835009> []

Haag-Streit Diagnostics (2020): OCTOPUS 900 Flexibility and reliability. Available at: [https://www.haag-streit.com/fileadmin/Haag-Streit\\_Diagnostics/perimetry/octopus\\_900/Brochures\\_Flyers/1511\\_7220444\\_02070\\_Broschuere-Octopus-900\\_Web\\_.pdf](https://www.haag-streit.com/fileadmin/Haag-Streit_Diagnostics/perimetry/octopus_900/Brochures_Flyers/1511_7220444_02070_Broschuere-Octopus-900_Web_.pdf) [accessed on 2021-08-12]

Helsedirektoratet (2017): Førerkortveileder 4. Syn (§§ 9–13). Available at: <https://www.helsedirektoratet.no/veiledere/forerkortveileder/syn-9-13#synfelt-praktisk>

Jorstad OK, Jonsdottir TE, Zysset S & Rowe F (2021): A traffic perimetry test that adheres to the European visual field requirements. *Acta Ophthalmol* **99**: e555–e561.

Kowa (2011): Kowa AP-7000 instruction manual. <https://ophthalmic.kowa-usa.com/wp-content/themes/kowa-eyecare/pdf/Kowa-Ophthalmic-Diagnostics-AP-7000-Manual.pdf>

Lawrence LI (1972): Mrs. Cinnabelle Morris Bride Of Dr. Benjamin Esterman *The New York times* 1972-12-04.

Oculus (2021): Oculus Twinfield 2 perimeter - Technical data. [WWW document]. [https://www.oculus.de/en/products/perimetry/twinfield-2/technical-data/#produkte\\_navi](https://www.oculus.de/en/products/perimetry/twinfield-2/technical-data/#produkte_navi) [accessed on 2021-08-12]

Optopol (2019): PTS 920 PTS 92W PTS 2000. [WWW document]. [https://www.optopol.com/public/files/pts\\_brochure.pdf](https://www.optopol.com/public/files/pts_brochure.pdf) [accessed on 2021-08-12]

Patterson G, Howard C, Hepworth L & Rowe F (2019): The Impact of Visual Field Loss on Driving Skills: A Systematic Narrative Review. *Br Ir Orthopt J* **15**: 53–63.

Rodenstock (2012): Peristat and Perimat - Automated perimeters - Operation manual.

Saxon W (1994): Benjamin Esterman, 88, Dies. *Ophthalmologist and Surgeon* New York: Times.

Schlossman A (2003): Mark Joseph Schoenberg MD: innovator, teacher, leader (1874-1945). *Surv Ophthalmol* **48**: 459–463.

Schoenberg M & Esterman B (1937): The Glaucoma Clinic of the Herman Knapp Memorial Eye Hospital. *Arch Ophthalmol* **17**: 666–673.

The Eyesight Working Group (2005): New standards for the visual functions of drivers. Brussels: European Commission.

United States Holocaust Memorial Museum (1996): Mark Esterman collection. [WWW document]. <https://collections.ushmm.org/search/catalog/irn90354> [accessed on 2021-07-19]

Visuscience (2021): *Front Projection Perimeter*. [WWW document]. <https://www.visuscience.com/product/9/case?page=1> [accessed on 2021-09-02]

Yanagisawa M, Kato S & Ochiai M (2018): Comparison of Esterman disability scores obtained using Goldmann perimetry and the Humphrey field analyzer in Japanese low-vision patients. *PLoS One* **13**: e0203258.

Received on September 24th, 2021.  
Accepted on December 29th, 2021.

*Correspondence:*  
Tomas Bro, MD, PhD  
Ögonmottagningen  
Höglandssjukhuset  
575 81  
Eksjö  
Sweden  
Email: tomas.kn.bro@gmail.com