Clinical Procedures in PRIMARY EYE CARE

David B. Elliott

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PREFACE

This textbook was written primarily as a teaching aid for undergraduate optometry students and for practitioners wishing to review their clinical practice. Chapter 1 discusses evidence-based optometry and how clinical tests and procedures are assessed in the research literature and how such reports should be critiqued. It also compares the various formats of an eye examination and discusses the theory behind the use of screening tests in primary eye care. Chapter 2 introduces the communication skills used in an eye examination and discusses the case history and how it should be performed. Tests are subsequently grouped together in terms of which system they assess: visual function (Chapter 3), refraction and prescribing (Chapter 4), binocular vision and accommodation (Chapter 6) and ocular health (Chapter 7). This layout was chosen because the organisation of the book is directed towards the assimilation of a problem-oriented approach that is built upon a systems examination (Section 1.3). Grouping the tests in this way, rather than in the order they are typically used in an eye examination, may also help students to better appreciate the relationship between the various tests that assess a particular system. To develop ocular health skills in discriminating between disease and the normal eye, it is essential to know many presentations that a normal eye can make and a brief description and collection of photographs of these normal variations is presented in Chapter 8 and the accompanying website to supplement the information provided in atlases of ocular disease. Chapter 9 completes the book with an introduction to some physical examination procedures that may be used in primary care eye examinations.

The 4th edition has been adapted to reflect the increasing use of technology in optometric practice and the ever-increasing ageing of the optometric patient population. This includes a section on optical coherence tomography (OCT) and suggestions of how to adapt some tests for older patients. Other improvements over the 3rd edition include:

- A dedicated website that includes video-clips of many clinical procedures, several in multi-screen format, and a large selection of fundus and slit-lamp photographs.
- An increased number of diagrams and photographs that are all provided in full colour throughout the text.
- A new chapter that introduces contact lens fitting and aftercare (Chapter 5).

Comments and suggestions for future editions

The advantages and disadvantages of each procedure are provided and where possible, the measurement procedure is based on evidence from the research literature. However, there is no doubt that tests and test methodologies have been included which may reflect our biases due to our particular training, research and clinical experience. There may also be errors and omissions. We therefore welcome any comments and suggestions that would improve any further editions. Please e-mail the editor, Professor David Elliott on: d.elliott1@bradford.ac.uk

Information relevant to students

There are many ways of conducting an eye examination and different ways to properly perform various tests or procedures and some may not appear in this textbook. In particular, in University primary care clinics it is the supervising clinician's decision as to which techniques or tests should be used in an eye examination. They are taking legal responsibility for the examination. If they indicate that a particular test needs using, use it! Once the patient has left and you are discussing the case with your supervisor, to further your learning, you should ask them about the advantages and disadvantages of their suggested technique and details of any supporting research evidence.

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EVIDENCE-BASED EYE EXAMINATIONS

DAVID B. ELLIOTT

1

1.1 EVIDENCE-BASED OPTOMETRY

Evidence-based optometry means integrating individual clinical expertise with the best currently available evidence from the research literature.[1] A significant amount of evidence-based eye care is associated with treatments and their effectiveness and this information is typically provided by the results from randomised controlled trials (RCTs) or the collation of results from several RCTs within systematic reviews and meta-analyses.[2] However, the diagnostic tests and procedures used in optometric practice should also be evidence based and what should always be avoided is the use of exam procedures based on anecdotal evidence, tradition or habit. The research literature should be regularly reviewed. There may be reports of newly developed techniques or instruments that are superior to the ones you typically use or even studies indicating that old and forgotten tests are actually better than commonly used ones.[3]

1.1.1 Reviewing the research literature

Currently professional bodies provide clinical guidelines that are based on research evidence and academic researchers write review articles, books and give lectures and this seems to be the preferred source of information for many optometrists.[4] You may not need to review the research literature yourself, although it seems likely that this will become more common in future years as evidence-based optometry becomes an integral part of the undergraduate and postgraduate curriculum.[4,5] If you wish to review the literature, one very useful free access website is PubMed (www.pubmed.com), which is provided by the US National Library of Medicine and includes the abstracts or summaries of all the main optometry and ophthalmology research journals. An increasing desire for research evidence to be freely provided to as many people as possible means that a growing number of the full articles are also free to access. Questions from clinicians on optometric internet/e-mail discussion groups can often be fully answered by a quick PubMed search that can provide a much better level of evidence than anecdotal suggestions based on one or two patient encounters. Full access to one or more of the main international optometry research journals, *Ophthalmic and Physiological Optics*, *Optometry and Vision Science*, *Clinical and Experimental Optometry*, *Journal of Optometry* and *Contact Lens and Anterior Eye* depends on which professional bodies you belong to, but note that the first three journals provide free access to a number of hot topic papers at www.whatshotoptometry.org.

1.1.2 Evaluating the usefulness of optometric tests

The usefulness of optometric tests is typically assessed by either comparing the test against an appropriate gold standard and/or assessing its repeatability.[6] For example, a test that is being used as an objective measure of subjective refraction should be assessed by how closely the results match subjective refraction results and new tonometers are assessed by their agreement with the results of Goldmann Applanation Tonometry (GAT).

Clearly the appropriateness of the gold standard test in these studies is critical. For example, Calvin and colleagues used the von Graefe phoria measurement as the gold standard test to assess the usefulness of the cover test and suggested that the cover test was occasionally inaccurate.[7] The gold standard in this area should be the cover test and not the von Graefe. The cover test is the only test that discriminates between strabismus and heterophoria, it is objective and not reliant on subject responses and subsequent studies have shown it to be far more repeatable than the von Graefe, which they indicate is unreliable and does not appear to warrant its widespread use.[3,8,9] The Calvin study[7] should have used the cover test as the gold standard and they would then have reported the limitations of the von Graefe. The gold standard test must also be appropriately measured. For example, Salchow et al. compared autorefraction results after LASIK refractive surgery against the gold standard of

subjective refraction.[10] Subjective refraction was an appropriate choice of gold standard, but was inappropriately measured. The authors concluded that autorefraction compared very poorly against subjective refraction post-LASIK. However, inspection of the results clearly indicates that the majority of the subjective refractions (particularly of the hyperopes) provided a result of plano. This suggests that a normal or near normal VA resulted in a 'brief' subjective refraction and a result of plano. Finally, any limitations of the gold standard test must be recognised. For example, GAT is known to provide high intra-ocular pressure (IOP) readings on thick corneas and low readings with thin corneas.[11] This has tended to be ignored until recently when significant reductions in IOP have been found after refractive surgery (section 7.7). If a tonometer that was resistant to corneal thickness effects had been compared to GAT, it would have been shown to be variable. The conclusion would have been that the new tonometer was somewhat variable compared to GAT.

The use of subjective refraction as a gold standard assessment of refractive error has meant that there has been little or no comparison of the various methods used in subjective refraction. Previous studies have tended to compare the various tests against each other. For example, West and Somers compared the various binocular balancing tests and found that they all gave similar results and concluded that they were therefore all equally useful.[12] Johnson and colleagues reported a similar finding when comparing subjective tests for astigmatism.[13] These are not surprising findings and are limited by an unhelpful study design. A very good but under-utilised approach is to use some measure of patient satisfaction as the gold standard. If patients are happy with the results of subjective refraction using a particular test, then the test must be providing appropriate results and vice-versa. Hanlon and colleagues used this approach in a comparison of techniques used to determine the reading addition.[14] They examined 37 patients that were dissatisfied with the near vision in their new spectacles. From the case history information in the review (recheck) examination, it was determined whether the improper add was too low or too high. For each patient, their reading addition was then determined using four methods (age, ½ amplitude of accommodation, NRA/PRA balance and binocular cross-cylinder). The percentage of adds for each test that gave the same result as the improper add or worse (higher than an improper add determined too high or lower than an improper add determined as too low) was calculated (section 4.14) The study would have been even better if they had confirmed that the patients were subsequently satisfied with their changed spectacles (i.e., that it really was the gold standard). This technique of using patient satisfaction as the gold standard test could be usefully employed to compare the various techniques used in distance refraction, particularly those that assess astigmatism and binocular balancing.

1.1.3 Analysis in clinical test comparison studies

In the past, test comparison studies tended to quantify the relationship between the test and gold standard using correlation coefficients. This is not appropriate for two reasons. First, a high correlation coefficient just indicates there is a strong relationship between the two sets of data and does not necessarily mean that agreement between the tests is good.[6,15] For example, if the test results were always twice as big as the gold standard test, the correlation coefficient would be 1.0, but agreement would be very poor. In addition, correlation coefficients are very much affected by the range of values used in the analysis.[6,15,16] If a small range of values is used in calculations the correlation coefficient is likely to be much smaller than if a larger range is used. This is highlighted in Figure 1.1, which shows a plot of correlation coefficients between visual acuity and other clinical measures of visual function versus the range of visual acuity of the subjects used in the studies. A much better analysis, commonly known as a Bland-Altman plot, shows the 95% confidence limits of the difference between the test and gold standard (Figure 1.2).[6,15] The extent to which the 95% Bland-Altman agreement figures are clinically acceptable should be discussed by the authors of a paper and ideally acceptable limits should be determined prior to any assessment.[6]

1.1.4 Analysis of test repeatability

Repeatability assesses the ability of a measurement to be consistently produced. It is sometimes called precision or reliability and particularly in older reports has been quantified in terms of correlation coefficients. The limitations of correlation coefficients have already been discussed and it is better to assess repeatability in terms of the coefficient of repeatability (COR) or similar.[6] This represents the 95% confidence limits of the difference between the test and retest scores and can be displayed using Bland-Altman plots (Figure 1.2).[15] Correlation coefficients can be used when comparing tests that do not use the same units, but their limitations need to be realised. In particular, a large

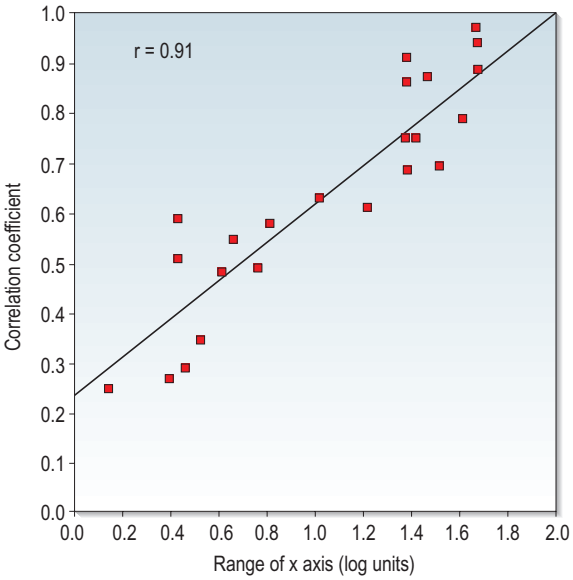


Fig. 1.1 Correlation coefficients from the literature between high contrast visual acuity and other spatial vision measures are plotted as a function of the range of high-contrast acuities in those studies. The solid line is the regression line and the correlation coefficient for the plotted data points is 0.91. (Redrawn with permission from Haegerstrom-Portnoy G, Schneck ME, Lott LA, Brabyn JA. The relation between visual acuity and other spatial vision measures. *Optometry and Vision Science* 77:653–62, ©The American Academy of Optometry, 2000.)

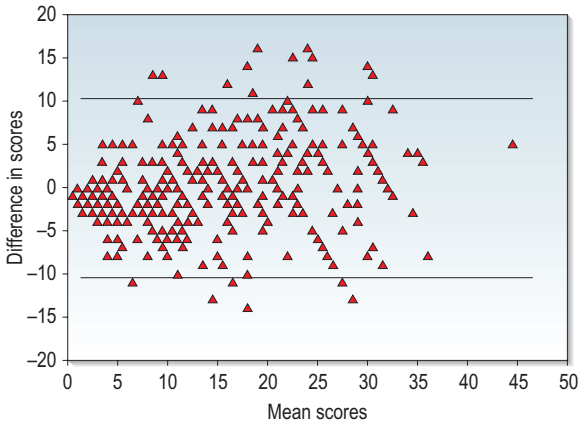


Fig. 1.2 A Bland-Altman plot showing agreement between optometrist grading of melanocytic fundal lesions and the gold standard assessment by an ocular oncologist versus the average score for each lesion. (Reprinted with permission from Hemmerdinger C, Beech M, Groenewald C and Damato B. Validation of an online referral guide for melanocytic fundus lesions. *Ophthalmic and Physiological Optics* 31:574–9. ©The College of Optometrists, 2011.)

range of values should be used, so that correlation coefficients are not artificially low. Concordance values (the percentage of patients getting exactly the same score on test and retest) have also been used to indicate that a test is repeatable. However, a high proportion of patients often obtaining exactly the same score on follow-up visits indicates that the step sizes on the test are too big rather than that the test is repeatable.[17] For example, a visual acuity chart containing only 20/20 (6/6) and 20/200 (6/60) lines would provide very high concordance but would be of very little value.

Repeatability studies providing COR data indicate the size of the change in score due to chance and a clinically significant change in score is anything larger than the COR (at least for tests with a continuous scale).[18] Repeatability appears to be a very important quality of a test, as an unreliable test is likely to correlate poorly with a gold standard and have poor discriminative ability.[19] As these studies are also relatively quick and simple, the results of repeatability studies should be available for all clinical tests.

1.1.5 Critically appraising a research paper

Research journals such as those listed earlier include a rigorous review process so that the majority of papers include minimal problems and many list the limitations of the study within the report. However, not all research reports necessarily provide accurate information and a study could be flawed for a variety of reasons.[20,21] In addition, articles on the internet and in professional magazines are unlikely to provide the same level of scrutiny and it is very useful to be able to critique a research report, rather than just accept its conclusions. Various criteria can be used to assess the methodological quality of research articles and a high quality paper should include the following[20,21]:

- The paper should be easy to read and understand. Particularly in the area of the assessment of clinical and diagnostic techniques, there should be little that a clinician cannot understand. The rationale behind any complicated statistical analyses should be explained in a simple way. A paper that is difficult to understand often indicates a poorly

written paper rather than any lack of understanding on the part of the reader.
- The introduction of a paper should include the purpose of the study and discuss pertinent previous work.
- The methods section should be clear and precise. Another researcher should be able to replicate the study from the information provided in the methods section. It is usually necessary to randomise the order in which tests are performed to ensure that there are no significant learning or fatigue effects that could affect the data.
- In studies where tests are compared against a gold standard, the clinicians should be blind to the results from the other test.
- The subject sample should be clearly outlined. A sufficiently large sample and a broad spectrum of subjects should be used to ensure no recruitment bias. In assessments of diagnostic tests, the patient sample must be representative of patients you would be examining in practice. For example, some Primary Open Angle Glaucoma (POAG) research studies include patients with moderate to severe POAG and healthy controls. This may be reasonable for an initial study, but likely tells you little about how well a new test would perform in discriminating between very early POAG and normal, healthy eyes in practice.
- In diagnostic studies, it is sometimes reported that a significant difference was found between a group of patients with an ocular abnormality and a control group. It should be noted that this only indicates that there is a difference between the averages of the two groups. It does not indicate how well the test predicts whether an individual patient has the abnormality or not.
- The authors may indicate the limitations of the study. The majority of research studies have some limitations and it is very helpful to the reader if the authors indicate them. It also suggests that the authors are not exaggerating the findings of their study.

1.2 'SCREEN EVERYBODY, SO I DON'T MISS ANY GLAUCOMA': IS THIS REASONABLE?

In many countries, glaucoma and other eye diseases are detected by 'opportunistic case finding' in that patients are self-selecting and they are detected as part of an eye examination that includes some assessment of ocular health and visual function.[22] Professional bodies within different countries generally provide evidence-based guidelines which tend to suggest which tests are appropriate for different patient demographics and perhaps for certain signs and symptoms. There has been a tendency, however, particularly with the increased use of clinical assistants within optometric practice (section 1.3.5) to increasingly 'screen' patients with tests such as visual fields and non-contact tonometry to attempt to 'not miss anything'.[23] This approach is examined below and highlights the importance of understanding diagnostic indices of optometric tests.

1.2.1 Diagnostic test indices and what they can tell us

New diagnostic tests must have their diagnostic ability compared to a gold standard reference. The research study will therefore determine how well a test can correctly identify 'abnormal' or 'normal' eyes as classified independently by a gold standard test or battery of tests. For example, new instruments or techniques that attempt to identify POAG are typically assessed against classifications of patients into glaucomatous and control groups by clinical evaluation of optic nerve head assessment, visual fields and tonometry.[24]

Please note that the following figures of sensitivity, specificity and prevalence are not accurate and have been simplified. Imagine a POAG test that correctly detects patients with POAG 95% of the time (the sensitivity of the test is 95%); if the test indicates that a patient has POAG, what are the chances that they actually have the disease? Is it 95%? If lower, how much lower? When considering this question, you must not only consider how good the test is at identifying POAG, but you must also consider how good the test is at correctly identifying someone as normal. Unfortunately all tests provide false positives: patients who have normal, healthy eyes who the test results suggest are abnormal. There are four possible outcomes from the results of a diagnostic test (Table 1.1)

Table 1.1 Possible outcomes of a screening test

	Diseased eye	**Normal eye**
Test says diseased	True positive, TP (hit)	False positive, FP (false alarm)
Test says normal	False negative, FN (miss)	True negative, TN

and this information is used to quantify how well the test discriminates between 'normal' and 'abnormal' eyes, by providing sensitivity and specificity values.

- Sensitivity is the ability of the test to identify the disease in those who have it.
- Sensitivity = TP / (TP + FN).
- Specificity is the ability of the test to correctly identify those who do not have the disease.
- Specificity = TN / (TN + FP).
- The false positive rate is simply 1 minus the specificity.
- Another important term to understand is the Predictive Value (PV), which has positive and negative forms.
- PPV or +PV is the proportion of people with a positive test result who have the disease. PPV = TP / (TP + FP).
- NPV or –PV is the proportion of people with a negative test result who do not have the disease. NPV = TN / (TN + TP).

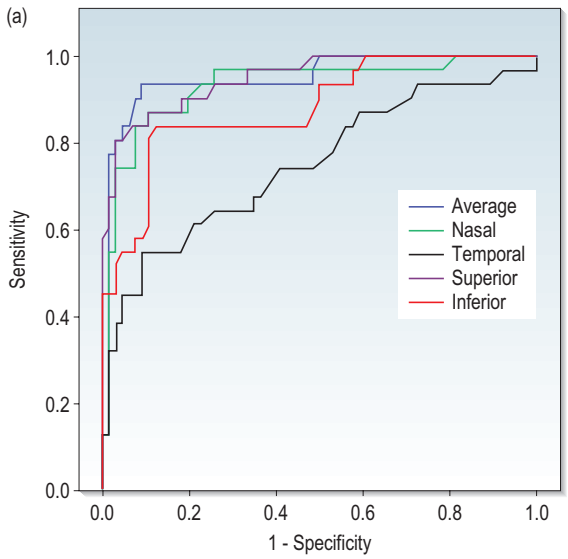
The reported sensitivity and specificity of a test will differ depending on the pool of patients examined, the gold standard used to determine the presence or absence of disease and the cut-off criteria used. Sensitivity and specificity values and plots of one against the other for a range of cut-off values in receiver operating characteristic (ROC) curves (Figure 1.3) are usually presented.

The ability of a diagnostic test to correctly identify patients with disease is highly dependent upon how prevalent the condition is (Bayes Theorem). For example, let us consider POAG and assume a prevalence in the over 40 population of 1%, and a diagnostic test for glaucoma with 95% sensitivity and 95% specificity. Table 1.2 shows the likely outcomes from 1000 patients. Nine or all 10 patients with POAG have a positive test result, but so have 50 patients with normal, healthy eyes. Returning to the question at the beginning of this section, if a POAG test that correctly detects patients with POAG 95% of the time (95% sensitivity) indicates that a patient has POAG, the chances that they actually have the condition (given a test specificity of 95%) is 17%! Detecting disease that has a low prevalence is very difficult no matter how good your diagnostic tests are because there are so few patients with the disease and so many people who don't have that disease. This also highlights that with diseases with low prevalence, you are better off using tests (or cut-off scores for a test) that have the highest specificity (limiting false positives) even if this lowers sensitivity and a small number with POAG (in its early stages) are missed.

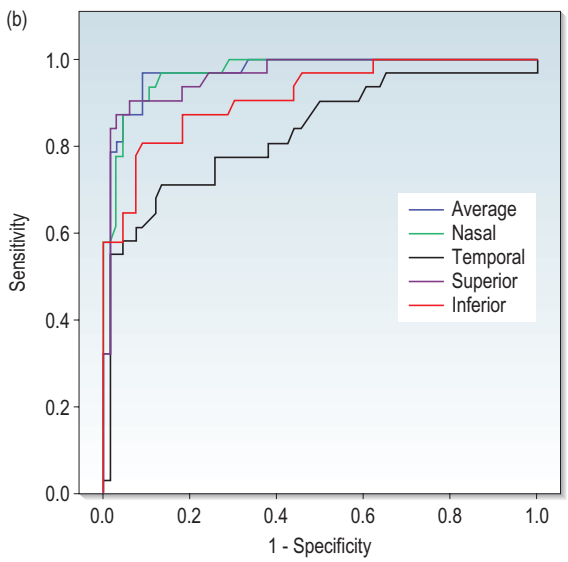
In addition to the diagnostic indices of sensitivity, specificity, PPV and NPV, likelihood ratios (LR) are

Table 1.2 Results for 1,000 patients from a 'glaucoma test' with 95% sensitivity and 95% specificity where the prevalence of primary open angle glaucoma (POAG) is either 1% or 10%. Data are also provided for the 1% prevalence group when the test is repeated

	Sensitivity 95% and specificity 95%		
	POAG prevalence, 1%	**POAG prevalence, 10%**	**Repeated testing (POAG, 1%)**
Patients with POAG	10	100	10
Patients without POAG	990	900	990
True positive	9.5 (9 or 10)	95	9
False positive	50	45	2.5
True negative	940	855	47.5
False negative	0.5 (0 or 1)	5	1
PPV	17%	68%	78%
NPV	~100%	99.4%	98%
LR+	19		
LR–	0.05		



	Superior	Inferior	Temporal	Average thickness
Nasal	0.633	0.153	0.001	0.601



	Superior	Inferior	Temporal	Average thickness
Nasal	0.839	0.138	0.005	0.962

Fig. 1.3 Receiver-operating characteristic (ROC) curve showing OCT ability (using nerve fibre layer thickness in various quadrants) to discriminate between optic nerve head drusen and optic disc oedema. (Redrawn with permission from Flores-Rodríguez P, Gili P and Martín-Ríos MD. Sensitivity and specificity of time-domain and spectral-domain optical coherence tomography in differentiating optic nerve head drusen and optic disc oedema. *Ophthalmic and Physiological Optics* 32:213–21. ©The College of Optometrists, 2012.)

becoming increasingly used to indicate diagnostic accuracy and unlike the predictive values, they are not dependent on the prevalence of the disease. A positive likelihood ratio (or LR+, sensitivity/1–specificity) expresses how much a positive test increases the odds that a patient has the disease. A negative likelihood ratio (or LR–, 1–sensitivity/specificity) indicates how much a negative test decreases the odds of having it. Charts have been developed that link a pre-test probability that a patient has a particular disease via a likelihood ratio column to indicate the post-test probability that a patient has the disease given either a positive or negative test result. The evidence-based medicine approach encourages the use of these indices and calculations for individual patient diagnosis. However, physicians still struggle to use these concepts and this would appear to have some way to go to be useable, but suggests the future direction of this area.[25]

1.2.2 Are there a lot of false positive referrals from primary eye care?

Figures for false positive referrals will vary dependent on the disease type (most of the reports present data from suspect glaucoma referrals, which will obviously have higher false positive rates than referrals for conditions such as cataract), the structure and funding model of the primary-secondary eye care system, the level of training, expertise and equipment, the introduction of locally agreed guidelines, etc, etc.[26] For these reasons, it is perhaps enough to say that it can be high and perhaps higher than you might expect. For example, in the most comprehensive study of its type to date, Bowling and colleagues reported a 46% false positive rate for suspect glaucoma from 2505 optometric referrals to the Oxford Eye Hospital over a 10-year period (1994–2004).[27]

1.2.3 Do false positive referrals matter?

Elmore and colleagues reported the false positive rate of the two main breast cancer screening tests to be 6.5% and 3.7%.[28] These translate to very good specificity values of 93.5% and 96.3%. Despite this good specificity, over a ten-year period, nearly one-third of the women screened had at least one false positive mammogram or clinical breast examination. This highlights that if you test healthy people often enough, they will sooner or later obtain a positive test result, i.e. a false positive. It has been shown that these false positive results have negative psychological effects on these women and likely their families.[29] Similarly, there is considerable and unnecessary worry and stress caused by a false positive result leading to referral to a secondary eye care system, in that some patients worry that they might be going blind. Patients should not be referred to secondary eye care on the basis of a slightly high intra-ocular pressure using a non-contact tonometer or a single positive visual field screening result. In addition to the psychological effects on patients and their families, the costs in terms of secondary eye care staff and patient time (including the delay that other patients will suffer because of busy clinics) prompted by a positive screening result should be considered.[23]

1.2.4 Reducing false positives 1: Only screen 'at risk' patients

Due to the high number of false positive results when screening patients for a disease with low prevalence (Bayes Theorem), it may be better to only screen those patients that are 'at risk'. In these patients, the prevalence of the disease is higher than in the general population. Table 1.2 considers the likely outcomes using the same test discussed earlier on patients with a family history of POAG where the prevalence of the disease is higher and for simplicity we will assume a figure of 10%. In total, 140 patients gave positive results, of which 95 had the disease (PPV = 68%). Note how much better the test performs when it is used in patients at higher risk of having the disease. The positive predictive value is also significantly improved if you just perform screening on all patients over 75 years of age or patients over 40 years of age who are black (African American or African Caribbean) or those with suspicious optic discs or high intra-ocular pressure. Burr and colleagues in their systematic review suggested that screening of patients with 'minor' risk factors including myopia and diabetes did not improve the PPV sufficiently and was not cost-effective.[22]

1.2.5 Reducing false positives 2: Repeat testing

Another way of keeping false positive referrals to a minimum, and imperative if you are intending to screen more than 'at risk' patients, is to repeat positive results. For example, as part of the ocular hypertension treatment study, Keltner and colleagues found 703 Humphrey visual field test results that showed abnormal (positive glaucoma hemifield test and/or Corrected Pattern Standard Deviation, $p < 0.05$) and reliable visual fields.[30] On retesting, abnormalities *were not* confirmed for 604 (86%)! The vast majority of visual field abnormalities were not verified on retest and confirmation of visual field abnormalities is essential for distinguishing reproducible visual field loss from long-term variability.

If the same glaucoma diagnostic test from Table 1.2, which suggested that 60 patients had POAG (only 10 did, a PPV of 17%), was repeated on these 60 patients, 9 or all 10 of the glaucoma patients would be identified, but 95% of the false positives (47 or 48) would now give a normal result. On retesting, positive results are found for 13 patients, of whom 10 have the disease (PPV = 77%). Of course, you could also combine both approaches by only screening at risk patients and repeating positive tests.

1.3 PRIMARY EYE CARE EXAMINATION FORMATS

The primary eye care examination must first and foremost adhere to the legal requirements where you are working. However, legal requirements tend to be provided in very broad terms. Some professional organisations that you belong to may also provide clinical guidelines of what your eye examination should include. These may be prescriptive or for guidance only. There are three main styles for a primary eye care examination, which could be used singularly or in combination: the database format, which uses a predetermined series of tests, the systems approach, which ensures an assessment of several systems and/or the problem-oriented approach, which focuses mainly on the patient's problems.[31,32] In addition, some parts of the eye examination could be performed by clinical assistants.

1.3.1 The database examination

A database examination style means using essentially the same set of clinical procedures in every

Table 1.3 Classification of tests/procedures into one of four clinical oculovisual systems

Visual*	Binocular*	Refractive	Ocular health
Case history	Case history	Case history	Case history
Visual acuity	Cover test	Visual acuity	Visual acuity
Colour vision	Motility	Retinoscopy	Biomicroscopy
Visual fields	Convergence tests	Autorefraction	Ophthalmoscopy
Contrast sensitivity	Accommodation tests	Subjective	Tonometry
Disability glare	Suppression tests	Near add determination	Gonioscopy
Pupil responses	Pupil responses Stereopsis	Keratometry	Pupil responses

**Other classifications discuss the sensory and motor systems rather than the visual and binocular systems and place suppression and stereopsis within the sensory system.*

examination. A large 'complete' database of information is collected to ensure that most patients' problems can be addressed using the information provided. This is the style of examination that will be used by students, because they need to practice the various clinical techniques to gain technical competence. Technical competence should be the aim for students in the early years of clinical teaching. A much greater task is gaining clinical competence and understanding the tests and their results, how they interact and how they can be used in differential diagnosis and to solve the patient's problems. Only once a student/practitioner has gained a high level of clinical competence should the database style of examination be abandoned and another approach used.

Although the database examination style is ideal for students, it is not for experienced practitioners. Often, if a large database is used, some data collected provide no useful information regarding the clinical diagnosis or treatment options. If patients require additional testing, because of the inflexibility of the approach, practitioners either perform the tests at the end of the examination, which can lead to them being late for subsequent examinations, or another appointment is made at a later date. At its worst, this style of examination could be said to provide some test data which are not used and of little value and provides a bias against performing additional procedures which may be of real benefit.

1.3.2 Systems examination

A systems examination style includes an assessment of visual function, the refractive and binocular systems and an ocular health assessment. The optometric examination is defined not by tests used, but by the systems that are assessed (Table 1.3). This approach is much more flexible as it does not demand that a certain collection of tests is used. In such an examination style, a minimum database has been gathered when each system has been tested. In summary, think in terms of assessing systems and not of using individual tests.

1.3.3 Problem-oriented examination

The problem-oriented examination aligns the examination around the problems reported by the patient. However, it does not only use tests that help solve the patient's problems as it is built upon a systems examination approach.[31,32] To perform a problem-oriented examination, the case history is critical as it guides the whole examination. From the information gained in the case history, you should attempt to deduce a list of tentative diagnoses (or several lists if more than one condition is suspected). For example, symptoms of blurred distance vision with normal near vision in a teenager could suggest the following tentative diagnoses (in order of likelihood): myopia, non-organic visual loss (section 4.12.6) and pseudomyopia. It is likely that visual acuity, retinoscopy and subjective refraction are all that is required to enable a differential diagnosis, although a cycloplegic refraction may be required if pseudomyopia is suspected. Other tests ensure an assessment of all the systems and depending on legal requirements and as a minimum these could include a cover and motility test (binocular system), assessment of pupil reflexes,

slit-lamp biomicroscopy and fundus biomicroscopy (ocular health assessment).

Although the problem-oriented examination requires a minimal database as required for legal reasons and to ensure that each system is assessed, this is not its major characteristic. Rather, it is distinguished by its variability. For example, if a 15-year-old patient complains of frontal headaches and eyestrain when reading, the most likely tentative diagnoses are uncorrected hyperopia or decompensated near heterophoria. Depending on results from other tests, tests used may include measuring fusional reserves, AC/A ratio, fixation disparity and cycloplegic refraction. If a 30-year-old patient complaining of sudden painless vision loss in one eye (>24 hours), the most likely tentative diagnoses would include a unilateral change in refractive error (i.e., suddenly noticed rather than sudden onset), optic neuritis and idiopathic central serous choroidopathy. None of the additional tests used in the previous example would be used. Instead, fundus biomicroscopy, photostress recovery time, central visual field and contrast sensitivity testing would be considered. In the latter case, an assessment of the refractive system may be limited to focimetry (lensometry), visual acuity and pinhole visual acuity. If the pinhole visual acuity suggests that visual acuity improvements are unlikely with an altered refractive correction, then a full objective and subjective refraction may not be necessary. The results from each test used in the examination are then considered and used to update the tentative diagnosis list(s) until a firm diagnosis (if possible) is made.

When using this style of examination, you must also be aware that any new or changed prescription should not produce symptoms. For example, the possible effect of an increased myopic correction on an esophoria should be determined prior to dispensing the spectacles: the increased myopia would likely increase the esophoria and you need to know whether it could become decompensated. Disadvantages of the problem-oriented examination include its dependence on the patient's symptoms. Obviously if a case history is not possible for any reason, a problem-oriented approach cannot be used and a database style of examination is necessary. In addition, there are also a variety of reasons why some patients may not disclose all their symptoms. These include:

- The patient might believe that their headaches are not associated with their vision or their eyes.
- The patient may assume that the clinician will identify a problem and would ask specifically about it if it was important.
- The patient could think that their slightly blurred vision is a normal consequence of ageing and so not mention it.
- The patient might not mention some symptoms such as flashes and floaters because they may think that they are not important and they may even believe that mentioning such symptoms would make them look foolish.

This further highlights the need to use the problem-oriented examination within a system assessment approach. It also indicates the importance of developing a good rapport with the patient to obtain a comprehensive case history (section 2.1). A further disadvantage of the problem-oriented approach is its complexity. To perform a problem-oriented examination, excellent communication skills are required to obtain a complete case history. A competent grasp of the information provided in the case history and how it relates to various ocular abnormalities is also needed, plus a knowledge of which tests are required to perform the huge variety of differential diagnoses. It is not suitable for the student clinician and can only be developed after significant experience has been gained.

1.3.4 Combination approach

Another approach is to gain a complete database of information during an initial examination of a patient, and then use a problem-oriented approach during subsequent examinations. This necessitates different appointment slots for first time and subsequent examinations, with the first time appointment slot being longer than for subsequent visits.

1.3.5 The use of clinical assistants

The rationale behind the use of clinical assistants in pre-examination is twofold:

- As clinical assistants perform certain tests that the optometrist would previously have performed, some of the optometrist's time is freed up. They could use this time to perform additional procedures or examine more patients per day.
- These procedures generally become more routinely performed.

After a period of training, clinical assistants should be able to competently perform any automated procedure, such as automated visual fields and focimetry, autorefraction and non-contact tonometry. The dangers of routinely screening all patients or all patients over 40 years of age with visual field tests and tonometry

(unless you are committed to repeating any positive test results) has been discussed in section 1.2. In addition, other simple tests could be performed such as colour vision and stereopsis screening and interpupillary distance (PD) measurement. It is not possible for a clinical assistant to complete the full case history, since history taking continues throughout the examination. However, assistants could record a baseline history that could be reviewed and augmented by the clinician. However, this approach provides less likelihood of a good rapport being established between patient and clinician, which is vital for an optimal examination result (section 2.1). Clinical assistants could also measure visual acuity with the patient's spectacles. However, important information can be obtained during visual acuity measurement in addition to the acuity score (section 3.2) and as an important part of the subjective refraction is to compare the final visual acuity (which the optometrist measures) with the habitual acuity, it appears best to have both measurements made by the clinician.

1.3.6 Should dilated fundus examinations be routine?

There has been considerable debate about whether a primary care eye examination should routinely include a dilated fundus examination (DFE).[33–36] Two main arguments, supported by clinical data, are proposed in favour of the DFE. The first is that a DFE increases the number of posterior pole anomalies detected.[33,34] In these studies, a non-dilated fundus examination with direct ophthalmoscopy was compared to a DFE using headband binocular indirect ophthalmoscopy (BIO) and direct ophthalmoscopy. Siegel et al. also used a monocular indirect ophthalmoscope examination as part of the non-dilated exam.[33] The poor field of view of the direct ophthalmoscope was particularly blamed for missing anomalies in the posterior pole as it is too small to examine the area quickly and easily. The second argument in favour of a DFE is that significant anomalies would otherwise be missed in the peripheral retina. Although many of the anomalies found in the peripheral retina are benign and do not need treatment, studies assessing the optomap system have shown that it missed treatable conditions in both the mid-peripheral and particularly the far peripheral retina when compared with a dilated fundus examination.[33–35,37,38]

Further study seems to be required. This should compare DFEs against an undilated fundus examination with fundus biomicroscopy, and most importantly the comparison should be made only for those patients where there are no symptoms, signs (including a small undilated pupil that would restrict the view) and/or risk factors that would normally prompt a DFE. It is possible that the better field of view and stereoscopic image provided by fundus biomicroscopy would limit the advantage of a DFE for the posterior pole in a patient with a reasonable pupil size and that very few treatable peripheral conditions would be missed. The majority of patients with peripheral retinal disease reported by Batchelder and colleagues had important risk factors including previous anterior segment

Box 1.1 Approximate order of testing for performing various procedures in a routine optometric examination of an adult patient

1. Case history
2. Focimetry (lensometry or vertometry)
3. Vision (unaided visual acuity)
4. Unaided cover test
5. Habitual visual acuity
6. Aided cover test
7. Near point of convergence
8. Worth 4-dot
9. Motility testing
10. Interpupillary distance measurement
11. Retinoscopy (and/or autorefraction)
12. Subjective refraction
13. Distance modified Thorington (or alternative)
14. Distance fusional reserves (or associated phoria measurement)
15. Amplitude of accommodation
16. Reading add determination (if required)
17. Near modified Thorington (or alternative)
18. Near fusional reserves (or associated phoria measurement)
19. Stereoacuity
20. Pupil reflexes
21. Slit-lamp biomicroscopy
22. Undilated fundus biomicroscopy (if patient has large pupils)
23. Tonometry
24. Visual field screening (or analysis)
25. (If dilating the pupils): anterior angle assessment
26. Binocular indirect ophthalmoscopy (and fundus biomicroscopy)
27. Post-dilation tonometry
28. Discussion with the patient

surgery, previous retinal detachment, strong family history of retinal detachment and high myopia.[35]

1.3.7 Test order

Box 1.1 provides a suggested order of testing for performing an efficient optometric examination. The exact testing to be performed will depend on the presenting complaint of the patient. Other test procedures should be inserted at appropriate times when the test result is not jeopardised by a preceding test and will not jeopardise tests that follow it in the eye examination. For example, refraction and pupil reflexes must be assessed prior to mydriasis and near muscle balance tests must be performed prior to cycloplegia. If the patient attends for an eye examination wearing their contact lenses, you may consider altering the order of your examination routine so that tests that can be completed with the lenses in situ are performed first (e.g. ophthalmoscopy, as issues associated with minification or magnification of the fundus image due to ametropia are minimised), then the lenses are removed before the remainder of the tests are completed.

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