Clinical research note

Extent and duration of practice effects on performance with the Farnsworth–Munsell 100-Hue test

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The extent and persistence of practice effects on serial performance in the Farnsworth-Munsell 100-Hue test (100-Hue test) were evaluated in an experiment in which six subjects performed the 100-Hue test up to 17 times over six weeks, and then once more after 7 months. A practice effect occurred which was highly statistically signiffcant for the group as a whole ($P < 0.001$) and for three individual subjects ($P < 0.05$). A practice effect was still evident 7 months after the last test performance. Error scores were reduced almost to zero after 5–10 retests so that it was unclear whether the effects of practice had disappeared or whether failure to improve further was a 'floor effect'. As a control against a floor effect, a second experiment was performed in which subjects' performance was impaired by placing neutral density fflters in front of their eyes (thus artiffcially raising their 100-Hue error score). Under these conditions, error scores continued to fall and were halved after 17 tests ($P < 0.03$). It is concluded that practice has a large effect on 100-Hue test performance which continues over many retests and for many months after testing.

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The Farnsworth–Munsell 100-Hue test (100-Hue test) is a widely employed test of congenital and acquired colour-vision deffciency which has been used for many years in the assessment of patients with visual disturbance[1–5]. Studies of the effects of practice upon 100-Hue test performance have produced conflicting results[6–9], perhaps because subjects may be divided into two populations: 'learners' and 'constant performers'[10]. Despite evidence that 100-Hue test performance may improve with serial testing, little is known about the extent of such practice effects: over how many retests does performance improve, and for how long after a test are such practice effects evident? Such questions may be important in clinical longitudinal studies such as the study of Bronte-Stewart *et al.*[11,12], where a cohort of diabetic school children has been assessed serially over many years, or the study of Lanthony *et al.*[13], where efficacy of Ginkgo biloba extract on visual function in diabetic patients was assessed over 6 months with the 100-Hue test and the Desaturated Panel D15 test. It is possible that practice effects may confound more important trends in the data due to changes in the subject's condition. The aim of the present study was to evaluate the limit of serial practice effects on 100-Hue test performance, and to examine how long any such practice effects persisted. The results suggest that practice has a large effect on 100-Hue test performance which continues over many retests and persists for many months.

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Experiment 1

Subjects and methods

Initially, six men aged between 23 and 32 years were studied. No subject had a history of eye disease (including congenital colour-vision deffciency), and none had any condition known to affect colour vision. None were taking any medication. Five of the subjects performed the 100-Hue test at least 17 times over a period of six weeks, and one performed it 10 times over the same period. The minimum interval between tests was 1 day and the maximum was 5 days. Seven months later, each subject performed the test once more. The 100-Hue test was administered according to the original instructions[14], with illumination by a simulated North Skylight (Northlight, Thorn EMI Lighting, London, UK) producing an illuminance on the caps of approximately 1700 lux. The Farnsworth scoring convention was used and viewing was monocular, each subject choosing at the beginning of the study which eye would be used. No time limit was set for completion of any single test. Subject motivation was ensured by offering a

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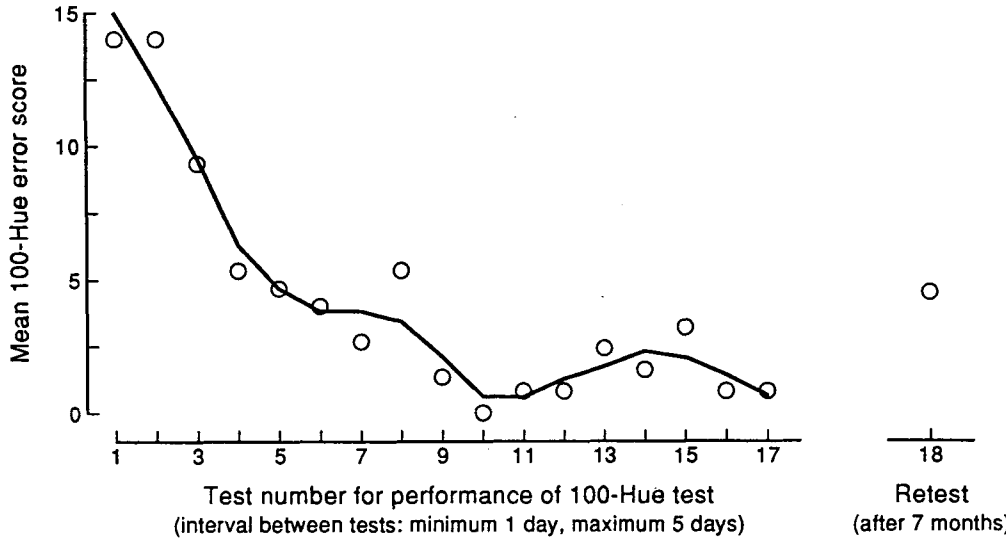

Figure 1 Effects of practice on performance (mean error score) in the 100-Hue test for six normal subjects. Improvement in performance with practice was highly signiffcant for the group, $P < 0.001$.

cash prize for the best mean score over the tests.

Statistical analysis was by the method of Jonckheere and Bower[15] for the detection of trends in learning data, to yield a P value for the signiffcance of the learning trend in each subject. The individual statistics were then combined as suggested by Jonckheere and Bower to yield a corresponding P value for the group as a whole.

Results and comments

Figure 1 shows the trend in 100-Hue error scores with repetitive testing. Data points are mean error scores for the group. *Figure 2* shows the same trend for each individual. It is apparent from *Figure 1* that a modest but signiffcant practice effect occurred. The test scores showed a trend towards better performance in all six subjects, which was statistically signiffcant ($P < 0.05$) in three of them and highly signiffcant ($P < 0.001$) for the group. In *Figure 1* the apparent absence of a practice effect in the ffrst retest was due largely to one subject whose scores initially deteriorated (see *Figure 2*). The other ffve subjects improved from the ffrst retest. *Figure 1* also shows the average score for the six subjects on a single retest after 7 months. This last data point indicates that at least some of the effects of practice were retained over many months, though uncertainty in the data precludes too strong a conclusion being drawn from this observation.

Inspection of *Figure 1* gives the impression that the learning effect is complete after 5–10 tests. But the subjects were producing very low error scores in later tests and the lack of improvement may have been because the error score could not fall any further (zero is the lowest error score possible on the 100-Hue test). To determine whether this was a genuine floor effect, a second experiment was performed with three of the subjects immediately after the 7-month retest.

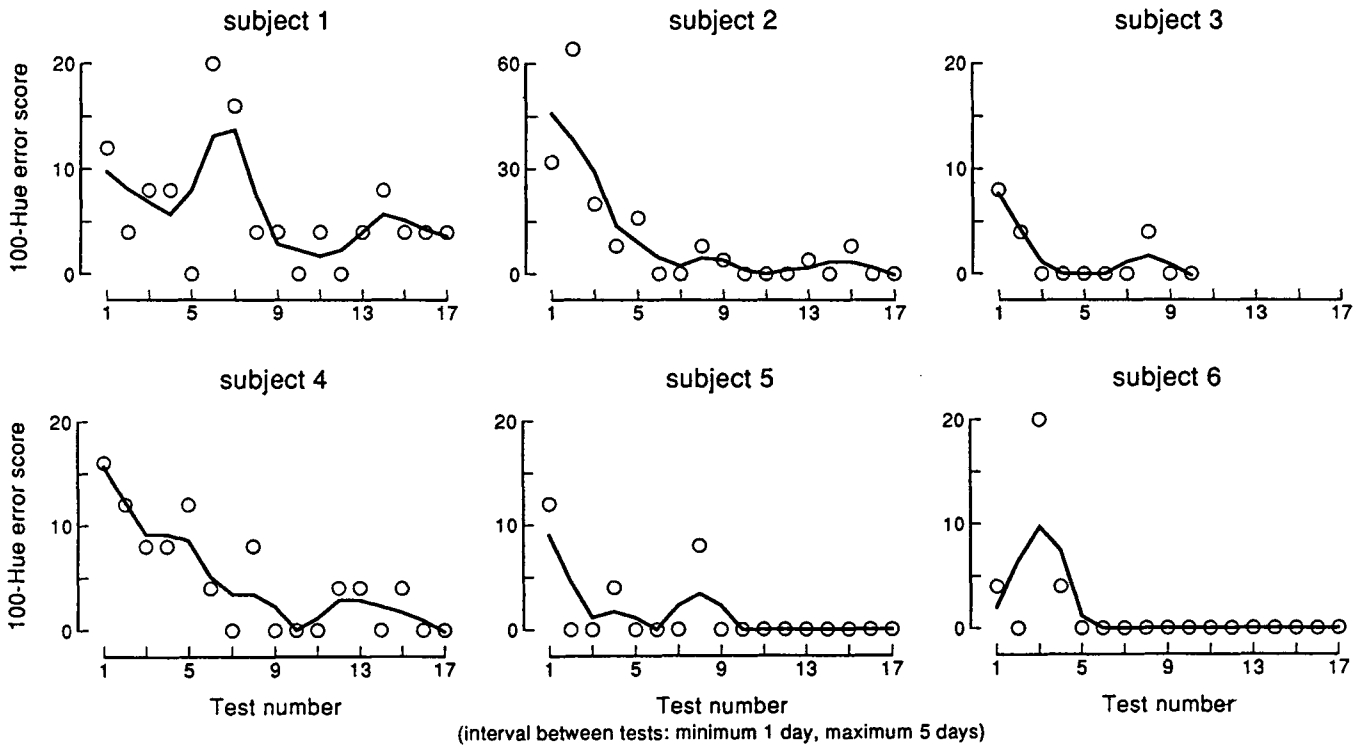

Figure 2 Effects of practice on performance (individual error scores) in the 100-Hue test for six normal subjects.

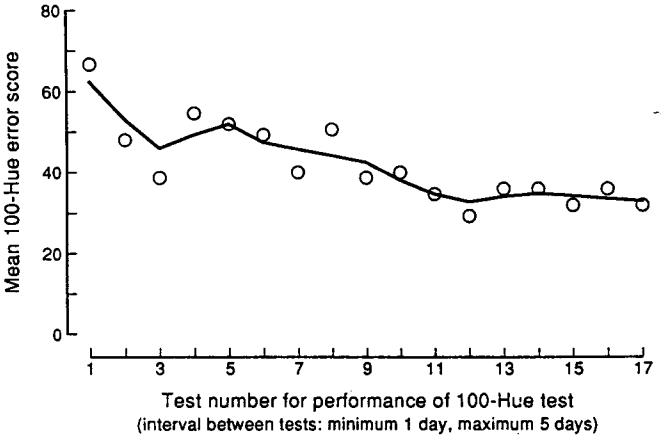

Figure 3 Effects of practice on performance (mean error score) in the 100-Hue test for three normal subjects who performed the test with a neutral density filter. The purpose of the filter was to eliminate any floor effects which may have been responsible for a loss of practice effects in Experiment 1. Improvement in performance with practice was highly significant for the group, $P < 0.05$.

Experiment 2

Subjects and methods

Subjects' discrimination performance was artificially impaired by their viewing the 100-Hue caps through a neutral density filter, which effectively reduced the illumination of the caps. Three different filters for the three subjects were used, of 2.1, 2.4, and 2.7 log units (a 2-log unit filter reduces the effective illuminance of the caps by a factor of 100). Each subject performed the test at least 15 times with the same filter over a period of 1 week. Test conditions were otherwise identical to those in Experiment 1.

Results and comments

Figure 3 shows the trend in error scores as the sequence of tests proceeded. As in *Figure 1*, the first test, here with a filter, is called Test 1. Each data point is the average score for the three subjects. The same filter was used throughout by each subject so that the *change* in error score between repetitions may be conveniently represented by averaging results for the three subjects. *Figure 4* shows the individual trends. Informal inspection of *Figure 3* suggests that further learning occurred; formal analysis of the data as in Experiment 1 showed that the practice effect was highly significant ($P < 0.005$) for the group as a whole, and was significant ($P < 0.05$) for two of the three subjects. The steady downward slope of the graph suggests that practice can continue to affect performance after many retests (these subjects had already performed the test 10–17 times previously).

Discussion

Two conclusions may be drawn from this study. First, practice effects can significantly affect 100-Hue test scores: in Experiment 1, the mean error score was reduced from 14 to approximately 2; in Experiment 2 the mean score was reduced by almost half. Second, learning may continue over many tests: scores improved over the entire 17 tests of Experiment 2, which itself was conducted after the subjects had performed the test 10–17 times in Experiment 1. In addition there is evidence that practice effects persist for many months.

These results confirm and extend the finding of a practice effect on a single retest, demonstrated by Farnsworth himself[14] and by Reeves *et al.*[8], and the observations by Fine and Kolbrick[9], and Breton *et al.*[10], and contradict the results of Chisholm[6] and Verriest[16], who found no practice effect. Chisholm studied patients with a variety of ocular diseases including tobacco amblyopia, Leber's hereditary optic atrophy, macular degeneration, squint, glaucoma, and 'endocrine disease' (sic), almost all of whom had exceptionally high 100-Hue error scores. It may be that in subjects with such severely deficient colour vision, any effects of practice on 100-Hue test performance are dominated by the overall colour discrimination loss. Alternatively, the high intra-subject variability of high scores may have made the detection of any practice effect impossible. In practice, few patients have such severe colour discrimination losses. Verriest *et al.*[7] acknowledged in a later study that there was a significant effect of prior experience on test scores obtained with monocular viewing.

A practice effect was observed here in one particular set of circumstances. Practice effects may, however, vary according to the testing regime employed; for example, the distribution of tests in time, or the use of different lighting conditions may affect learning. Nevertheless, it is likely that practice effects will prove to be important in the repeated assessment of subjects with the 100-Hue test. This finding has important consequences for investigators and clinicians using the 100-Hue test. Clinicians should be aware of the extent and duration of 100-Hue test practice effects when interpreting clinical data, and researchers should incorporate appropriate safeguards against the effects of practice (such as control groups and randomized test sequences) into the design of experiments using the 100-Hue test.

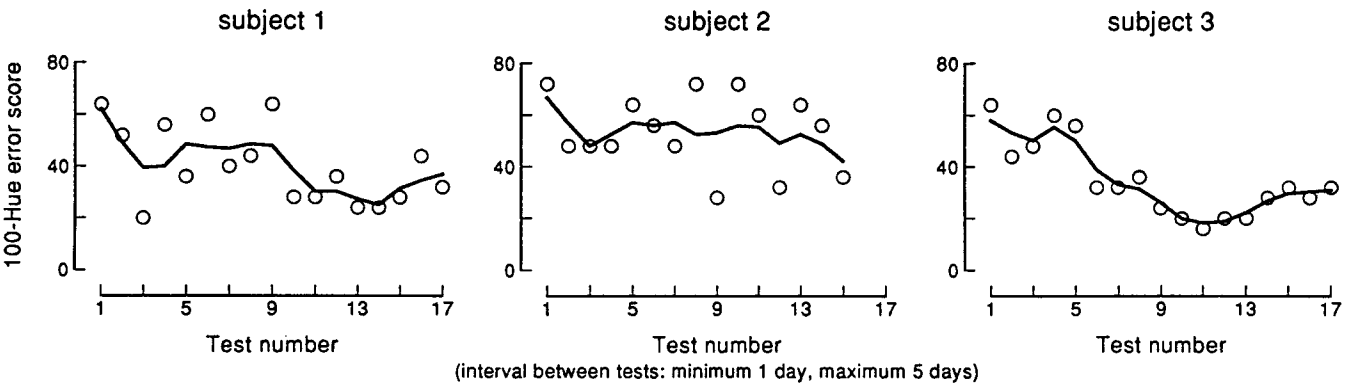

Figure 4 Effects of practice on performance (individual error scores) in the 100-Hue test for three normal subjects who performed the test with a neutral density filter.

Acknowledgements

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References

1. Francois, J. and Verriest, G. On acquired deficiency of colour vision. *Vision Res.* **1,** 201–219 (1961).
2. Kinnear, P. R., Aspinall, P. A. and Lakowski, R. The diabetic eye and colour vision. *Trans. Ophthalmol. Soc. UK* **92,** 69–78 (1972).
3. Griffin, J. F. and Wray, S. H. Acquired colour vision defects in retrobulbar neuritis. *Am. J. Ophthalmol.* **86,** 193–201 (1978).
4. Bresnick, G. H., Condit, R. S., Palta, M., Korth, K., Groo, A. and Syrjala, S. Association of hue discrimination loss and diabetic retinopathy. *Arch. Ophthalmol.* **103,** 1317–1324 (1985).
5. Hardy, K. J., Lipton, J., Scase, M. O., Foster, D. H. and Scarpello, J. H. B. Detection of colour vision abnormalities in uncomplicated type 1 diabetic patients with angiographically normal retinas. *Br. J. Ophthalmol.* **76,** 461–464 (1992).
6. Chisholm, I. A. An evaluation of the Farnsworth–Munsell 100 Hue test as a clinical tool in the investigation of ocular neurological deficit. *Trans. Ophthalmol. Soc. UK* **89,** 243–250 (1969).
7. Verriest, G., van Laethem, J. and Uvijls, A. A new assessment of the normal ranges of the Farnsworth–Munsell 100-Hue test scores. *Am. J. Ophthalmol.* **93,** 635–642 (1982).
8. Reeves, B. C., Hill, A. R. and Aspinall, P. A. The clinical significance of change. *Ophthal. Physiol. Opt.* **7,** 441–447 (1987).
9. Fine, B. J. and Kolbrick, J. L. Field dependence, practice and low illumination as related to the Farnsworth–Munsell 100-Hue test. *Percept. Mot. Skills* **51,** 1167–1177 (1980).
10. Breton, M. E., Fletcher, D. E. and Krupin, T. Influence of serial practice on Farnsworth–Munsell 100-Hue scores: the learning effect. *Appl. Optics* **27,** 1038–1044 (1988).
11. Bronte-Stewart, J. M., Cant, J. S. and Craig, J. O. The detection of early visual loss in young diabetics. *Proc. Roy. Soc. Med.* **63,** 14–16 (1970).
12. Bronte-Stewart, J. M., Cant, J. S. and Craig, J. O. Colour vision in young diabetics. *Doc. Ophthalmol. Proc.* **39,** 377–381 (1983).
13. Lanthony, P. and Cosson, J. P. Evolution de la vision des coleurs dans la retinophathie diabetique debutante traitee par extrait de Ginkgo biloba. *J. Fr. Ophthalmol.* **10,** 671–674 (1988).
14. Farnsworth, D. The Farnsworth–Munsell 100-Hue test for the examination of color discrimination. Munsell Color Company Inc. Baltimore, MD, USA (1957).
15. Jonckheere, A. R. and Bower, G. H. Non-parametric trend tests for learning data. *Br. J. Math. Stat. Psychol.* **20,** 163–186 (1967).
16. Verriest, G. Further studies on acquired deficiency of color discrimination. *J. Opt. Soc. Am.* **53,** 185–195 (1963).

Book review

Optometric Guide to Surgical Co-management

Debra Bezan, Kathy D. Halverson, Kathleen Schaffer and Pam Thomas

Butterworth-Heinemann, Boston, USA, 1994, 128 pp., £20.00 0 7506 9329 0

In the preface to this American publication the authors' stated aim is 'to provide an easy-to-use guide to management of the postsurgical patient for use in optometric offices providing postoperative care'.

This book is a relatively slim volume consisting of just five chapters and an appendix providing a quick reference guide to postsurgical complications.

Nearly half the book is taken up by the first chapter on cataract surgery. Indications for, contraindications to and techniques of surgery are described. I was surprised at the lack of detail regarding preoperative assessment of intraocular implant power, the use of multifocal implants and management of postoperative refraction. There is some discussion of optical reasons for suture removal and a technique is outlined for suture cutting. The rest of the chapter concentrated essentially on medical complications of cataract surgery and postoperative symptoms and their significance.

Chapter 2 is on glaucoma surgery and is presented in a similar style. There are some indications as to when, in the event of ophthalmological complications, the optometrist should refer the patient back to the ophthalmologist. I noted the description of the use of a compressive shell or bandage contact lens in the management of leaking wounds – lack of detail here would almost certainly deter the inexperienced optometrist from trying these techniques.

Chapter 3 is on penetrating keratoplasty. Again there is insufficient information on postoperative refraction and its management. Wound leak and its management by bandage lenses is again mentioned.

Chapter 4 is on radial keratotomy. There is a useful section on indications and suitability for the procedure and a less useful one (due to its brevity) on postoperative refraction and its notoriously varied course. An additional chapter or section on the photorefractive keratectomy (PRK) technique would have been useful in these rapidly changing times of refractive surgery. Perhaps the authors do not regard PRK as a 'surgical' procedure?

The final, short chapter is on squint surgery. I could find very little mention of optometric involvement here although a few optometric and orthoptic tests are listed as part of the preoperative ocular examination.

The quick-reference guide to complications of ocular surgery is just that – very brief and, by its very nature, rather simplistic.

I found this book a great puzzle. Its title suggests that it might be of assistance to an optometrist involved in 'co-management' of certain postsurgical cases. The concept of 'co-management' or 'shared care' will be interpreted differently around the world, for a wide variety of reasons.

The book contains, in a rather compressed format, quite a lot of ophthalmological information. However, I felt that the amount of optometric detail was minimal. As a result I found it rather disappointing. It does provide a brief, summarized reference source to some aspects of surgical ophthalmology and as such might appeal to some optometrists. However I did not feel that the content really lived up to the initial aims set out by the authors.

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