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PRIMARY eyecare

Vision – it's more than meets the eye

Most people think that optometry is all about eyes.

Well, this is true at one level but most optometrists will tell you that optometry is about eyes and vision and seeing and perception.

The eye is just the first part of an amazingly complex system that converts energy from the visible spectrum into electrical signals that transmit visual information deep into the occipital lobe. Visual processing starts in the eye when the image projected onto the retina is separated into different image channels before being transmitted to the brain.

Disruption to the early stages of this process of seeing can have a profound effect on a person's ability to perceive and interact with the world around them. Even relatively low levels of visual impairment can interfere with a person's ability to perform routine activities at home or at work.

Reduced visual acuity is a classic example of visual impairment and at levels below 6/12 will rule out the ability to drive legally. For many people in New Zealand this small loss of vision is the first step in loss of independence and has huge impact on personal freedom.

Because of the importance of vision and the effects of visual impairment on quality of life and on general health and well-being there is a huge amount of research into the causes, treatments, and responses to vision loss. In this issue of primary Eyecare Quarterly we have collected a selection of some recent vision research which we hope will be of interest to our GP colleagues.

New Light on the Mind's Eye: The Pupillary Light Response as Active Vision

Mathôt S, and Van der Stigchel S. "New Light on the Mind's Eye: The Pupillary Light Response as Active Vision." Current Directions in Psychological Science 24.5 (2015): 374–378.

The eye's pupils constrict in brightness and dilate in darkness. The pupillary light response has historically been considered a low-level reflex without any cognitive component. However, recent studies have dramatically changed this view: The light response depends not only on a stimulus's brightness but also on whether you are aware of the stimulus, whether you are paying attention to it, and even whether you are thinking about it. There is a link between the pupillary light response and eye-movement preparation: When you intend to look at a bright stimulus, a pupillary constriction is prepared along with the eye movement before the eyes are actually set in motion.

This preparation allows the pupil to rapidly change its size as your eyes move from bright to dark objects and back again.

The authors describe an experiment which shows that your pupils adjust to an object if you attend to it, even if you do not look at it directly. This is important, because elements in a visual scene can differ strongly in brightness: for example, your keyboard might be dark, whereas your monitor might be bright.

While looking at your monitor, you

Pupillary light response reflects mental state in exquisite detail

may covertly (i.e., without moving your eyes) attend to your keyboard to localize your fingers. Since perception benefits from an optimal pupil size, if you attended to the keyboard with a pupil size that was tuned to the brightness of the monitor this would result in suboptimal perception. Therefore, even though the benefit is presumably small, a link between the pupillary light response and visual attention is beneficial.

Although the light response is the primary determinant of pupil size, the pupil also dilates in response to arousal in a way that is independent of the light response. Here "arousal" is used in its broadest sense. In general, anything that increases arousal also elicits a pupillary dilation: sexy pictures, mental arithmetic, keeping something in working memory, effortful listening, and the list goes on.

But why does arousal trigger a pupillary dilation and seemingly disturb the balance between visual acuity and sensitivity? This may be related to an earlier proposal by Aston-Jones and Cohen (2005) proposal that there are two modes of behaviour, exploitation and exploration, which are both linked to pupil size. During exploitation, arousal is low and you are focused on one task, such as reading a book, which requires fine visual discrimination. In this mode, visual acuity is more important than sensitivity, and the pupil therefore constricts. During exploration, arousal is high, and you are in a vigilant state, ready to detect mates, predators, and other things that require immediate action. In this mode, visual sensitivity is more important than acuity, and the pupil therefore dilates.

For this reason Mathôt and Van der Stigchel suggest that far from being a simple low-level reflex, the pupillary light response reflects mental state in exquisite detail. It is truly a mind's eye.

Oestrogen, ocular function and low-level vision: a review

Hutchinson CV, Walker JA, Davidson C. "Oestrogen, ocular function and low-level vision: a review" JEndocrinol. 2014 Nov;223(2):R9-18. doi: 10.1530/JOE-14-0349. Epub 2014 Aug 20.

Over the past 10 years, a literature has emerged concerning the sex steroid hormone oestrogen and its role in human vision. Hutchinson et al. review evidence that oestrogen (oestradiol) levels may significantly affect ocular function and low-level vision, particularly in older females. In doing so, they examined a number of vision-related disorders including dry eye, cataract, increased intraocular pressure, glaucoma, and age-related macular degeneration. In each case, they found oestrogen, or lack thereof, to have a role. They also included discussion of how oestrogen-related pharmacological treatments for menopause and breast cancer can impact the pathology of the eye and a number of psychophysical aspects of vision.

Emerging evidence suggests that appropriate levels of oestrogen (and in particular oestradiol (E2)) may be a significant factor in the maintenance of healthy visual function, particularly in older females. Oestrogen is abundant in the mammalian eye and its receptors (ERs) have been found in the retina, cornea, lens, iris, ciliary body, conjunctiva, lacrimal and meibomian glands of male and female eyes across a number of species including humans. It follows that oestrogen levels may impact vision through its effects on cells of the eye.

The existence of ERs in the conjunctiva, lacrimal and meibomian glands suggests that oestrogen may modulate tear production and it is observed that tear production decreases after menopause. Although some studies have found that hormone replacement therapy (HRT) leads to a decrease in tear function, the majority have shown that dry eye improves after HRT. Topical E2 drops appear to alleviate dry eye symptoms and E2 has also been implicated in the health of the lens. There is some evidence that HRT might reduce the risk of increased lens opacity and cataract development.

There is an apparent weak protective association between use of oral contraceptive pill and the development of cortical cataract and animal research showed that E2 treatment prevents induced

cataracts in rats. It is noted that patients prescribed tamoxifen, a selective ER antagonist, for the treatment of breast cancer are more likely to develop cataracts.

Oestrogen has also been identified as a potential factor in age related diseases that affect the retina, such as glaucoma and age-related macular degeneration (AMD). A recent review concluded that oestrogen (at the proper dose) should be considered a potential therapy for glaucoma, particularly in menopausal women who suffer from the condition*. A number of studies have examined the utility of HRT for lowering IOP and, by extension, reducing glaucoma risk. These studies have indicated mixed results. Some report no effect of hormone therapy on IOP and one study found that HRT raises IOP in postmenopausal females with dry eye syndrome. However, most studies observed that hormone therapy significantly lowers IOP in menopausal and postmenopausal women. Contraceptive use and postmenopausal HRT lower the risk of developing AMD in older women. This is particularly the case for neovascular AMD**.

While Hutchinson et al report that the majority of studies reviewed do suggest that oestrogen regulates a range of ocular functions, they also note that a clear consensus has yet to emerge. And in a word of caution they point out that many of the clinical studies they have reviewed are limited by relatively low numbers of subjects and/or may not have appropriate control groups. However, despite these limitations, they conclude that on balance, there is emerging support for the view that endogenous oestrogen plays an important role in ocular pathology and low-level vision.

[* (Wei et al. 2012) ** (Haan et al. 2006, Feskanich et al. 2008)]

Random Word Recognition Chart Helps Scotoma Assessment in Low Vision

MacKeben M, Nair U, Walker L, and Fletcher D. "Random Word Recognition Chart Helps Scotoma Assessment in Low Vision." Optometry and Vision Science 92.4, (2015): 421-428.

Printed words as test material have been common in vision care for at least 150 years because of the importance of reading in cultural and educational contexts. Two aspects of vision are most frequently tested: reading acuity and critical print size; and reading performance (speed and accuracy). However, the two most important elements of the linguistics of reading are syntax and semantics. In continuous text both can be used to increase reading speed and fluency by allowing the reader to associate a probability with each word that determines the likelihood that a certain word may follow. If a sequence of words loses the syntactic and semantic coherence, reading becomes more difficult and slows down.

The study made by MacKeben et al. sought to evaluate the use of a vision test based on random word sequences that prevents the prediction of upcoming words by linguistic criteria and is simple to score in a clinical setting and to determine if the presence and location of a central scotoma in patients with a maculopathy influences the characteristics of reading errors.

They tested reading performance for continuous text and random words monocularly in a group of 231 subjects (aged 16 to 97 years) collecting data from 136 eyes of subjects with a maculopathy and 65 with normal or near-normal vision

Reading speed was always higher for continuous text than for random word sequences in normally sighted subjects and in patients with maculopathies. The number and type of errors made depended only negligibly on age and visual acuity. However, the difference between the degree of predictability of continuous text vs. random words had differing effects on the two groups.

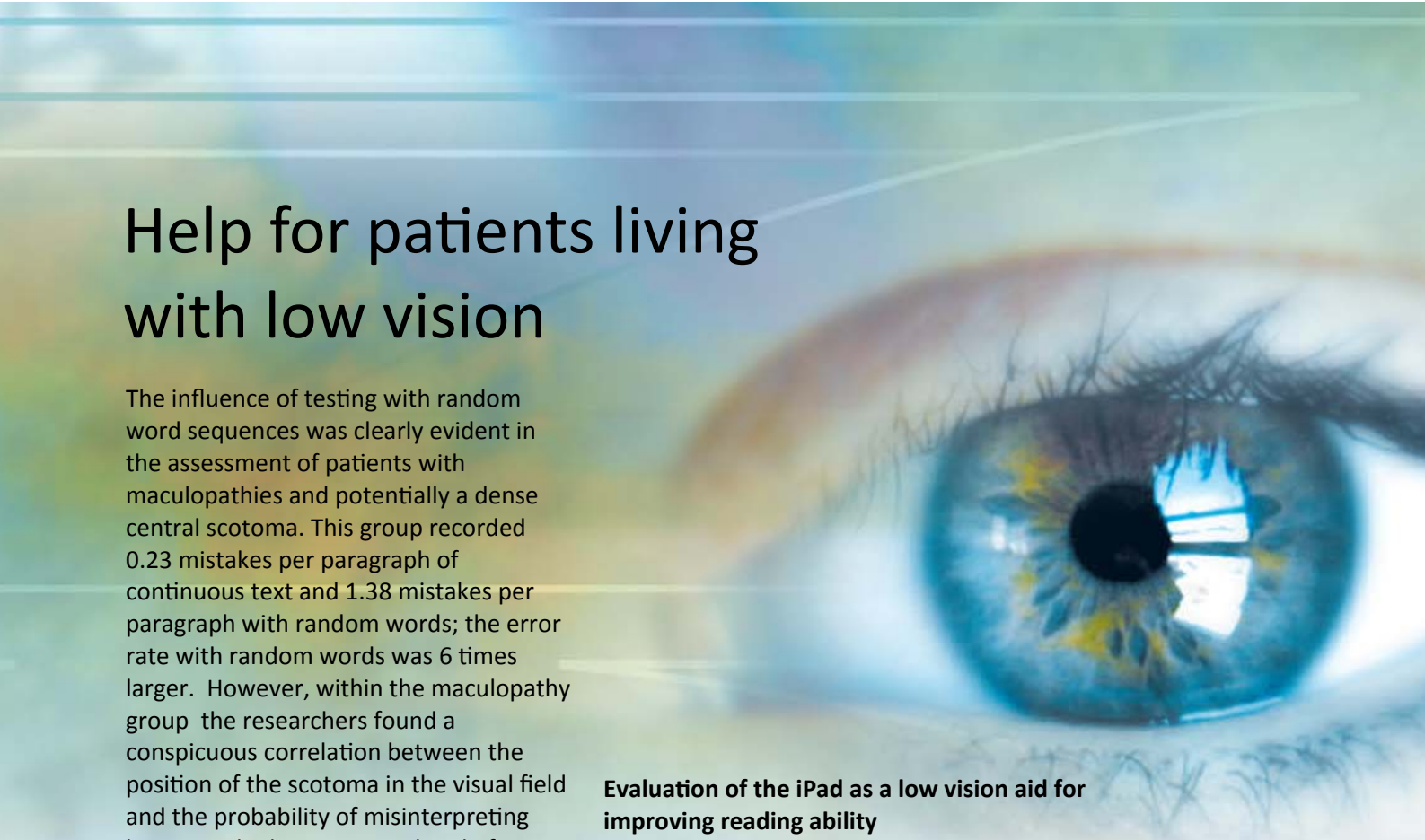
In the performance of the normally sighted subjects the difference between the two test materials was vastly different: from a total of 718 paragraphs of continuous text they made 21 mistakes (0.029 mistakes per paragraph); and from a total of 723 paragraphs of random words they made 317 mistakes (0.438 per paragraph). Thus the mistake rate for normal sighted subjects was about 15 times greater with random words than with continuous text.

Help for patients living with low vision

The influence of testing with random word sequences was clearly evident in the assessment of patients with maculopathies and potentially a dense central scotoma. This group recorded 0.23 mistakes per paragraph of continuous text and 1.38 mistakes per paragraph with random words; the error rate with random words was 6 times larger. However, within the maculopathy group the researchers found a conspicuous correlation between the position of the scotoma in the visual field and the probability of misinterpreting letters at the beginning and end of words. Patients with a dense scotoma right of fixation made more ''right errors'' by missing letters at the end of words, whereas those with a scotoma left of fixation made more ''left errors'' by missing letters at the beginning of words.

(Note: This analysis disregarded scotomas lying above or below fixation because English is read horizontally meaning that a scotoma above or below fixation is not likely to interfere with reading performance.)

MacKeben et al. suggest that the unpredictability of random word and letter sequences renders reading performance highly dependent on eyesight and less dependent on reading skill and educational level. Furthermore, recurrent right or left errors can indicate the presence and location of a scotoma and prompt referral for investigation. In addition, the frequent mistakes have a potential benefit for educating patients about how their scotoma can affect their vision. This can be necessary because many patients cannot visualize their visual field defects, and they are often surprised to see the repeated pattern of mistakes they make to one side of words. Making them aware of this connection can facilitate their rehabilitation.



Evaluation of the iPad as a low vision aid for improving reading ability

Haji S, Sambhav K, Grover S, and Chalam K. "Evaluation of the iPad as a low vision aid for improving reading ability" Clin Ophthalmol. Dec 19;9 (2014):17-20. doi: 10.2147/OPTH.S73193.

Haji et al. point out that while traditional low vision aids are effective at helping the blind and partially sighted to 'read', tools such as hand magnifiers, illuminated magnifiers, stand magnifiers, and closed circuit television are effective, they are also cumbersome to use and are not user-friendly. They note that the iPad (Apple Inc., Cupertino, CA, USA) has built-in software that allows image magnification, contrast enhancement, and brightness modulation. The zoom feature offers magnification in levels up to five times (equivalent to a +20 D magnifier).

There were 228 participants in the study, ages ranged from 58–92 years; the vast majority (81%) were 60 years and older. Seventy-three participants had AMD, 109 had diabetic retinopathy, and 46 had other vision conditions. Only 22% could read standard newsprint-sized text (N8) without the help of the iPad. With the help of the iPad, 94% participants with impaired vision were able to read standard newsprint-sized text (N8) or smaller text ($P<0.01$).

Although the conclusion that the iPad can be used to assist people with low vision is in itself unsurprising, the researchers suggest there are added benefits over other traditional low vision aids that make the iPad more suitable: the tactile gestures to magnify or reduce text offer each patient an optimal atmosphere to improve reading ability and consequently improve the quality of life; plus, the iPad is lightweight and mobile, with adjustable magnification, contrast, and brightness amenable to most patients; and finally the iPad is less expensive and far more portable than other electronic vision enhancement systems previously available.