A review of the impact of glare and fatigue on visual function

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Abstract

Educators are expected to formulate a broad understanding of the visual function of students they support with vision impairment, often beginning by reviewing the clinical measurements that are included in an ophthalmology report. However, these clinical measurements may not reflect the student's observed visual capacity, due to overestimation of the student's visual function. Further, these clinical measurements may sometimes not reflect the real life factors that potentially impact on the student's visual function. This paper will review the educational and ophthalmic literature to investigate two such important factors – glare and visual fatigue. It is anticipated that educators will be able to apply the results of this review, to broaden their understanding of visual function beyond clinical measurements, and to better support students with vision impairment.

Keywords: glare, visual fatigue, vision impairment

Introduction

An essential part of the education and care of a student with vision impairment is to ensure that he or she accesses timely ophthalmic assessment, as soon as suspicion arises regarding their eyes and vision. An important aim of ophthalmic assessment is to determine the student's visual function, by applying age appropriate tests that measure visual acuity and visual fields. The student's visual function is then commonly reported in terms of the numerical score they have achieved on these tests. The process is known as one of obtaining clinical measurement.

Clinical measurements are used by a variety of professionals for a variety of purposes. For example, eye health professionals will consider clinical measurements when obtaining a student's diagnosis and in developing a therapeutic management plan for remediating their ophthalmic condition (Blais, 2011). As a further example, school administrators may apply clinical measurements to defined criteria to determine the student's eligibility for disability and educational support funding.

A variety of educators will use clinical measurement to estimate the student's likely visual performance and capacity within the school environment. However, educators have long known that the visual function indicated by the student's clinical measurements often fails to align with the visual performance observed in the classroom. Perhaps this discrepancy is not surprising, given that the clinical environment has usually been optimized to reveal the student's visual threshold, by controlling the factors that might impact on vision. For example, attention is paid to clinical illumination to diminish glare. Also, clinical assessments are often scheduled to lessen the potential impact of fatigue on the student's performance; as for example, the practice of scheduling assessments for young students early in the day. Similarly, most vision tests used to assess students in ophthalmology clinics are, by nature, brief, and do not place prolonged visual demand on the student compared to tasks such as reading, that occur over a day in the classroom.

A dilemma thus arises for educators in understanding the true nature of a student's visual function from their clinical measurements. This paper will discuss the notion that certain factors can impact on the visual function indicated from the student's clinical measurements, and will identify two such important factors –(a) glare and (b) visual fatigue. A review of the ophthalmic and educational literature that has examined the nature and impact of glare and visual fatigue will be presented. It is anticipated that this information can be used by educators in our schools, to develop a broader understanding of the students they support.

THE NEED TO UNDERSTAND THE STUDENT'S VISUAL FUNCTION

Students with vision impairment face many hurdles in their learning including concept and literacy development; access and participation in curriculum and learning activities; social interaction, independence and self-organisation; and orientation and mobility (South Pacific Educators in Vision Impairment, 2015). There is no question that the role of educators in supporting such students is a complex and challenging task. A particular challenge is developing a broad understanding of the student's visual function. Educators are usually privy to the clinical measurements found in the student's ophthalmology report for this purpose. However, D'Andrea and Farrenkopf (2000) addressed the risk of overestimation of a student's visual function from clinical measurements. They commented that it is unlikely the student will experience the "perfect environmental circumstances" found in the ophthalmology clinic and concluded that "as a result, the student may not be able to function as well as reported visual acuity results would imply" (p. 14).

A salient example of such a shift in visual function from that determined clinically to that displayed in a student's real-life environment is apparent in functional vision assessments (Fazzi & Naimy, 2010). These types of assessments are frequently conducted within the classroom environment, with one component of the assessment determining the student's preferred print size for reading. A study by Miller (2015) examined the preferred near print size for a group of 45 students with vision impairment aged 5-17 years, who underwent low vision functional assessment. The results showed that every student indicated a preference for an increased print size from that indicated in their ophthalmology report.

Clinical measurements can perhaps be used as a starting point for educators in their understanding of a student's visual function within the school environment. This understanding can then be broadened by considering the factors that might impact on the student's reported visual function. Two such factors that are frequently identified in the literature are (a) glare and (b) visual fatigue. Mason (1997) discussed the educational implications of many types of ophthalmic disease that cause vision impairment, with glare and visual fatigue cited as the most common symptomology needing consideration and management within the classroom setting.

FACTORS THAT IMPACT ON VISUAL FUNCTION - GLARE AND VISUAL FATIGUE

Several ocular structures play a role in managing the light that naturally enters the eye. The iris, a pigmented structure within the anterior chamber of the eye, supports an aperture known as the pupil. When the eye is exposed to light the pupil reacts by constricting to prevent excessive light from entering the eye (Lens, Nemeth &Ledford, 2008). Further, the retina or the inner nervous layer of the eye contains cells known as the pigment epithelium that act to absorb light as part of the visual process; this absorption prevents light scatter within the eye (Forrester, Dick, McMenamin & Roberts 2008). However, van den Berg (1991) described the eye as optically imperfect and despite the role these particular ocular structures play in managing light, the avoidance of glare even in eyes without ophthalmic disease is near impossible. That author commented that glare is a lifelong experience that begins in early childhood, and is one that is generally visually debilitating.

Mainster and Turner (2012) defined glare as environmental luminance entering the eye, that is too intense or variable across the visual field, and as luminance that does not aid vision (p. 588). van den Berg, Franssen and Coppens (2010) further commented that structures within the eye may naturally contribute to the intraocular light scatter that causes glare. These structures include the cornea and the lens that cause a level of light scatter as refracting surfaces; the iris and sclera as they are not completely opaque, allowing light falling on both structures to pass through to the retina; and the retina itself as it does not absorb all light falling on it, but rather reflects some light backwards causing scatter. Also, aging and vision impairment are known to increase a person's susceptibility to the effects of glare (Mainster & Turner, 2012). Further, a study by De l'Aune, Geruschat and Smith (1992) determined that experiencing glare was the most significant hindrance to orientation and mobility. By way of clarification, Aslam, Haider and Murray (2007) identified three types of glare, these being (a) disability glare, (b) adaptation glare and (c) specific light phenomena.

1. Disability glare

Disability glare describes the "...loss of retinal image contrast as a result of intraocular light scatter or straylight" p. 354 (Aslam et al., 2007). Mainster and Turner (2012) commented that disability glare impairs visual function by reducing the contrast of retinal images by spreading a veiling luminance across the images falling on the retina. This loss of contrast makes the image appear fainter, as if being viewed through a fog (Bex, 2011). The impact on contrast is most significant in dimmer environments as the retinal photoreceptors active in low levels of light – the rods – require increased contrast for visual detection (Barbur & Stockman, 2011). Disability glare may also cause the phenomenon known as colour desaturation that causes a loss of colour tone (Beckman, Scott & Garner, 1992). Further, van den Berg et al. (2010) stated that the person experiencing disability glare may also complain of hazy vision and increased glare hindrance.

The major ophthalmic pathological causes of straylight include cataract, corneal disturbances, turbidity in the vitreous such as floaters (van den Berg et al., 2010) and when iris and fundus hypopigmentation exist (van den Berg 1986). It is also known that people who have undergone refractive surgery or those who wear contact lenses may also experience disability glare from straylight (van den Berg et al., 2010).

The effect of disability glare has been examined in several studies. van den Berg (1986) noted that in people with ophthalmic disease, the impact on visual function, specifically on contrast sensitivity from light scatter was significant. However, a similar impact was not found on the participant's visual acuity, leading the author to conclude that in the presence of disability glare"...for these patients, the visual acuity test gives a rather limited impression of their visual handicap " (p. 327). In a further study, van den Berg et al. (2010) similarly noted that the effect of disability glare on visual function may be significant, particularly when the person is vision impaired.

Ivers, Mitchell and Cumming (2000) have reported on the impact of disability glare within the studied population from their Blue Mountains Eye Study, a cross sectional census-based survey of eye disease (N=3654). When participants (including those with and without ophthalmic disease) were found to have disability glare, it was noted that their contrast sensitivity was reduced (at 6 cycles per degree), with a significant association with such self-reported visual disabilities as night driving difficulties, reduced ability for face recognition and detail recognition while watching television. They concluded that the presence of disability glare may have been a predictor of reduced visual function in the study participants. Similarly, Barstow, Bennett and Vogtle (2011) stated that in the presence of disability glare, the loss of contrast sensitivity was reported as a major concern for people with all forms of vision impairment, even those with mild vision impairment.

2. *Adaptation glare*

Mainster and Turner (2012) defined visual adaptation as the response of the eye to a range of luminance in the direct visual environment. Despite the eye's capacity to adapt, a delay is often encountered and glare can be experienced. This delay is known as adaptation glare and typically occurs when a person moves from either a well-lit to a dark, or a dark to a well-lit environment (Aslam et al., 2007). As adaptation to lower levels of illumination takes longer, the disturbance to visual function can be prolonged when moving from well–lit to dark (Mainster &Turner, 2012). As with disability glare, when a person has vision impairment the effects of adaptation glare will be more pronounced (Aslam et al., 2007).

3. *Specific light phenomena.*

Aslam et al (2007) also included a third term in their definition of glare. They used the term specific light phenomenon to describe a variety of visual experiences such as halos that are a common phenomenon noticed by people with cataract.

Glare and Photophobia

It is worth noting that the term photophobia is routinely used in the literature and is occasionally interchanged with the term glare. However, Mainster and Turner (2012) differentiated the two terms and described photophobia as "an abnormal response to normal illumination exaggerated by abnormal light exposure" (p. 589). They further commented that photophobia is often accompanied by blepharospasm (involuntary twitching, blinking or closing of the eyelids) and cortical pain (headache), and may occur when ophthalmic disease is present. Hence, glare and photophobia should not be used interchangeably as nomenclature that describes visual phenomena related to light.

Management of Glare

An interest in the concept of glare and its measurement has bridged numerous professions including ophthalmology, illumination engineering, visual neuroscience and neurology (Mainster & Turner, 2012). Within the AMA Guides to Evaluation of Ophthalmic Impairment and Disability, Blais (2011) commented that adjustment should be made for glare sensitivity, delayed glare recovery, photophobia, and reduced or delayed light and dark adaptation. However the capacity to accurately measure glare to permit fair adjustment continues to be a challenge, and as Mainster and Turner (2012) commented " many clinical disability glare testers have been developed, but results have been variable and no widely accepted testing protocols exist despite over two decades of study" (p. 590). Perhaps it is safe to conclude that the existence and impact of glare are well recognised in the literature, but the capacity to accurately measure that impact continues to evade professionals.

From an educational perspective, Anthony (2008) commented that glare is the most common complaint of a person with vision impairment, and that time should be dedicated to analysing and minimising classrooms for sources of glare such as gloss finishes on furniture, glare from computer monitors and other shiny surfaces including paper. It is further recommended that students undergo specific low vision evaluation and remediation for the effects of glare.

Griffin-Shirley, Trusty and Rickard (2000) described simple but efficient ways of managing glare within the school environment that included (a) positioning of the student to avoid glare; (b) use of sunglasses and hats within the classroom and outside to support the student with glare generally, and (c) classroom modifications such as alternative lighting and window covering. McGregor & Farrenkopf (2000) suggested use of sunglasses and hats to reduce glare during the period of adjustment experienced when moving between light and dark environments. Fazzi and Naimy (2010) reinforced the need for adequate assessment of the student to support selection of optical quality lenses that provide suitable ultraviolet protection, specifically according to the ophthalmic condition present. Geruschat and Smith (2010) also suggested changing the angle of viewing away from the glare to improve visibility, while Kamei-Hannan and Ricci (2015) discussed the use of electronic displays that provide appropriate illumination for reading.

By reviewing the literature it becomes apparent that glare can have a significant impact on a student's visual function, and therefore warrants judicious consideration by the educator.

Visual fatigue

As with glare, visual fatigue occurs commonly in people with vision impairment, and is often accompanied by headaches and general discomfort (Kamei-Hannan & Ricci, 2015). Lusk and Corn (2006) have commented that visual fatigue is one of the important challenges for students with vision impairment who are learning to read print, and that it is "...among the visual difficulties that challenges the enthusiasm of these students" (p. 3). Visual fatigue can have a flow-on effect, dampening visual function, causing blurred vision, or even causing a significant reduction in visual acuity (Sticken & Kapperman, 2010). Abadi and Bjerre (2002) discussed the impact of visual fatigue on people with infantile nystagmus, for example when a person has oculocutaneous albinism. They noted that the oscillations (involuntary eye movements) associated with the nystagmus increased as the person became tired, resulting in a reduction in their visual function.

Management of Visual fatigue

Within the educational literature that addresses vision impairment, it is perhaps more common that a person's visual stamina rather than their visual fatigue is described. Visual stamina is the person's capacity to maintain their visual efficiency over time. Koenig and Holbrook (2010) noted that increasing levels of visual fatigue can cause visual stamina to fluctuate and even wane. Visual stamina is frequently referred to in the context of reading. For example, Koenig and Holbrook (2010) described measuring visual fatigue in students reading over extended periods of time, to assess if they have sufficient stamina to complete their required tasks, with a level of comfort. They further commented that a student with vision impairment may not enjoy reading and this may in part be due to insufficient comfort for the task. Vik and Lassen (2010) discussed findings from research on a group of students with severe vision impairment and their experiences with reading. The majority of students identified a lack of stamina as one of the challenges they faced when working with printed materials. Kamei-Hannan and Ricci (2015) further commented that students with vision impairment who experience visual fatigue may have less energy to comprehend what they are reading.

Holbrook, Koenig and Rex (2010) provided strategies for dealing with visual fatigue that occurred during reading, including monitoring the student for signs of visual fatigue such as headache, frustration, tired eyes and increasing reading errors; encouraging rest periods when visual fatigue occurs; changing the mode of delivery of the reading material, for example from print to audio and the transition to Braille; and the physical repositioning of the student to generally improve their comfort.

This review of the literature concerning visual fatigue reveals that it is a factor that warrants serious consideration when determining a student's visual function in the environment where their learning will occur.

Discussion

Australian education systems are mandated by The Disability Discrimination Act, 1992 (Australian Government ComLaw, 1992) and the Disability Standards for Education, (Australian Government ComLaw, 2005) to fulfil obligations to students with disability, including students with vision impairment. To achieve these obligations, educators need to broadly understand the individual student's visual function. This calls for an understanding beyond the clinical measurements reported in an ophthalmology report. However, as D'Andrea and Farrenkopf (2000) have commented "...the snapshot of a child's visual abilities at a particular time, one that is provided by a clinical examination, may not be an accurate picture" (p. 14). Thus, it becomes imperative that the educator is aware of the factors that can impact on the student's ability to function visually.

An understanding of the student's visual function is vital for enhancing their classroom performance, but also extends to such issues as educational accommodations, or adjustments made for the existing vision impairment. Steer and Gentle (2007) commented that the aim of such accommodations is to "level the playing field" (p. 32) to enable students with vision impairment to demonstrate their learning. Further, they described the need for educational integrity when deciding upon suitable accommodations, according to the individual student's needs. To achieve this integrity, educators must again draw on a broad understanding of the student's visual function.

With the recent recognition of Specialist Teachers (Vision Impairment) as early intervention service providers for the Better Start Initiative (Australian Government, Department of Social Services, 2015), educators will be well-placed to assume a lead role in supporting children with vision impairment. Further, as the Better Start Initiative transitions to the National Disability Insurance Scheme (Australian Government, Department of Social Services, 2015), educators can provide direct and consultative support to people with disability, in needs assessment and planning. Again, a broad understanding of the person's visual function will be foundational to ensuring the educator's advice meets the individual needs and goals of the person being supported.

The review of the ophthalmic and educational literature presented in this paper has identified two factors that have the potential to impact significantly on visual function – (a) glare and (b) visual fatigue. An assessment protocol that includes identification, measurement and then calculation of the impact of glare and visual fatigue would be ideal, but does not currently exist. Although the literature available on glare and visual fatigue is somewhat limited, the studies discussed here demonstrate the importance of educators becoming aware of the potential impact of such factors on a student's visual function, and that both be considered when deciding on accommodations and strategies to support the student with vision impairment.

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