Visual performance and ocular abnormalities in deaf children and young adults: a literature review

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ABSTRACT.
Visual defects are common in deaf individuals. Refractive error and ocular motor abnormalities are frequently reported, with hyperopia, myopia, astigmatism and anomalies of binocular vision, all showing a greater prevalence in deaf individuals compared with the general population. Near visual function in deaf individuals has been relatively neglected in the literature to date. Comparisons between studies are problematic due to differences in methodology and population characteristics. Any untreated visual defect has the potential to impair the development of language, with consequences for education more generally, and there is a need to improve screening and treatments of deaf children.

Key words: binocular vision – deaf – reading – refraction – vision

The review process involved a comprehensive electronic literature search from various data bases: OneFile, Health Reference Center Academic, Social Sciences Citation Index (Web of Science), SciVerse ScienceDirect (Elsevier), Science Citation Index Expanded (Web of Science), Medline (NLM), MLA International Bibliography, American Psychological Association (APA), Project MUSE, ERIC (US Department of Education), Oxford Journals (Oxford University Press), SpringerLink, SAGE Journals, Wiley Online Library, PMC (PubMed Central), Nature.com (Nature Publishing Group) and Google Scholar. The following key words and combinations of words were used: deaf children vision, vision and deafness, deaf vision, eye and deafness, refractive and deaf, optometry and deaf, refraction and deaf, vision and hearing, ophthalmological and deaf, ophthalmological and hearing, vision and ear, deaf and blind, eye and deaf, deaf vision and reading, reading and deaf, vision reading and deaf, near vision and deaf, near vision and hearing impaired.

Introduction

In the UK, there are approximately 1 per 1000 children born each year with hearing impairment defined as a hear-
ing loss in the better ear of more than 40 dB averaged over 0.5, 1, 2 and 4 kHz (Fortnum et al. 2001). The British Society of Audiology (2004) classifies hearing levels as shown in Table 1.

Visual defects and ocular abnormalities have consistently been documented as being more prevalent in deaf individuals (Table 2) than comparable groups of hearing individuals (Pollard & Neumaier 1974).

Refractive error is common in deaf individuals including children with uncomplicated deafness (i.e. no evidence of family history, congenital or deafness caused by infective or metabolic disease) even allowing for enmetropization. There is little consensus as to whether refractive errors are more frequent in the congenitally deaf than in those who acquire deafness at a later stage of life (e.g. Guy et al. 2003).

Ophthalmological screening regimes have been implemented for deaf children in an attempt to maximize visual abilities and minimize social and educational disadvantages (Siatkowski et al. 1993; Guy et al. 2003; Hanioglu-Kargi et al. 2003). Despite the awareness that visual abilities are essential in a non-hearing world, it would seem that very little attention has previously been given to near visual function, and in particular reading. Perfetti & Sandak (2000) suggest that the use of phonology (the study of how sounds are organized and used in languages) is associated with higher levels of reading skills among deaf readers and that ‘the effectiveness of the visual channel is not an issue’. On the other hand, Martin et al. (2012) suggested that deaf children who have reduced dynamic visual acuities may also have reduced vestibular responses and reading difficulties. Children with congenital vestibular abnormalities displayed gross motor developmental problems that the authors suggested may impede the usual ocular motor/vestibular relationship. This in turn could impact on visual stability and hence acquisition of reading (Martin et al. 2012).

Table 1. The British Society of Audiology (2011) classified hearing levels.

| Mild hearing loss | 20–40 (dB) | Able to hear and repeat words spoken in normal voice at 1 m |
| Moderate hearing loss | 41–70 (dB) | Able to hear and repeat words spoken in raised voice at 1 m |
| Severe hearing loss | 71–95 (dB) | Able to hear some words when shouted into better ear |
| Profound hearing loss | >95 (dB) | Unable to hear and understand even a shouted voice |

Table 2. Percentage of deaf individuals with visual defects or ocular abnormalities in 21 studies.

<table>
<thead>
<tr>
<th>Studies</th>
<th>No of subjects N</th>
<th>Male</th>
<th>Female</th>
<th>Age range</th>
<th>Visual defects/Ocular Abnormalities %</th>
<th>Data collection institution</th>
<th>County of origin</th>
</tr>
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<tbody>
<tr>
<td>Braly 1938</td>
<td>422</td>
<td>*</td>
<td>*</td>
<td>2–20</td>
<td>46</td>
<td>Deaf School USA</td>
<td></td>
</tr>
<tr>
<td>Stockwell 1952</td>
<td>980</td>
<td>555</td>
<td>405</td>
<td>4–12</td>
<td>58</td>
<td>Deaf School USA</td>
<td></td>
</tr>
<tr>
<td>Suchman 1967</td>
<td>104</td>
<td>51</td>
<td>53</td>
<td>5–20</td>
<td>50</td>
<td>Deaf School Canada</td>
<td></td>
</tr>
<tr>
<td>Alexander 1973</td>
<td>572</td>
<td>*</td>
<td>*</td>
<td>5–20</td>
<td>33</td>
<td>Deaf School USA</td>
<td></td>
</tr>
<tr>
<td>Pollard &amp; Neumaier 1974</td>
<td>511</td>
<td>303</td>
<td>208</td>
<td>5–17</td>
<td>75</td>
<td>Deaf School USA</td>
<td></td>
</tr>
<tr>
<td>Mohindra 1976</td>
<td>77</td>
<td>33</td>
<td>42</td>
<td>1–14</td>
<td>45</td>
<td>HEC Israel</td>
<td></td>
</tr>
<tr>
<td>Regenbogen &amp; Godel 1985</td>
<td>150</td>
<td>92</td>
<td>58</td>
<td>6–22</td>
<td>49</td>
<td>HEC USA</td>
<td></td>
</tr>
<tr>
<td>Woodruff 1986</td>
<td>460</td>
<td>*</td>
<td>*</td>
<td>1–18</td>
<td>55</td>
<td>Deaf School Canada</td>
<td></td>
</tr>
<tr>
<td>Leguire et al. 1992</td>
<td>505</td>
<td>*</td>
<td>*</td>
<td>1–14</td>
<td>35</td>
<td>HEC USA</td>
<td></td>
</tr>
<tr>
<td>Siatkowski et al. 1993</td>
<td>54</td>
<td>28</td>
<td>26</td>
<td>1–14</td>
<td>61</td>
<td>HEC USA</td>
<td></td>
</tr>
<tr>
<td>Armitage et al. 1995</td>
<td>83</td>
<td>41</td>
<td>42</td>
<td>1–14</td>
<td>61</td>
<td>HAC UK</td>
<td></td>
</tr>
<tr>
<td>Brinks et al. 2001</td>
<td>231</td>
<td>*</td>
<td>*</td>
<td>1–14</td>
<td>48</td>
<td>Deaf School USA</td>
<td></td>
</tr>
<tr>
<td>Mafong et al. 2002</td>
<td>114</td>
<td>60</td>
<td>54</td>
<td>1–18</td>
<td>31</td>
<td>HES USA</td>
<td></td>
</tr>
<tr>
<td>Hanioglu-Kargi et al. 2003</td>
<td>104</td>
<td>68</td>
<td>36</td>
<td>7–20</td>
<td>40</td>
<td>Deaf School Turkey</td>
<td></td>
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<tr>
<td>Guy et al. 2003</td>
<td>122</td>
<td>61</td>
<td>61</td>
<td>0.7–16.8</td>
<td>43</td>
<td>CDC UK</td>
<td></td>
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<tr>
<td>Khandaker et al. 2009</td>
<td>223</td>
<td>142</td>
<td>81</td>
<td>5–15</td>
<td>19</td>
<td>Deaf School Oman</td>
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<tr>
<td>Bakhshaei et al. 2009</td>
<td>50</td>
<td>19</td>
<td>31</td>
<td>5–15</td>
<td>32</td>
<td>Deaf School Iran</td>
<td></td>
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<tr>
<td>Sharma et al. 2009</td>
<td>226</td>
<td>112</td>
<td>114</td>
<td>1–14</td>
<td>22</td>
<td>HEC USA</td>
<td></td>
</tr>
<tr>
<td>Gogate et al. 2009</td>
<td>901</td>
<td>554</td>
<td>347</td>
<td>4–14</td>
<td>24</td>
<td>Deaf School India</td>
<td></td>
</tr>
<tr>
<td>Bist et al. 2011</td>
<td>279</td>
<td>154</td>
<td>125</td>
<td>5–20</td>
<td>28</td>
<td>Deaf School Nepal</td>
<td></td>
</tr>
<tr>
<td>Abah et al. 2011</td>
<td>680</td>
<td>373</td>
<td>325</td>
<td>5–18</td>
<td>21</td>
<td>Deaf School Nigeria</td>
<td></td>
</tr>
</tbody>
</table>

* No data available. HEC, Hospital eye clinic. HAC, Hospital audiology clinic. CDC, Child development centre.  
† Retrospective study.
Visual defects – refractive and binocular vision abnormalities

Refractive and binocular vision abnormalities have typically been the most commonly reported. The prevalence of hyperopia, myopia and astigmatism is between 18% and 39% (Pollard & Neumaier 1974; Mohindra 1976; Regenbogen & Godel 1985; Guy et al. 2003; Gogate et al. 2009) and binocular vision abnormalities (e.g. strabismus) between 5.3% and 18% (Regenbogen & Godel 1985; Hanioglu-Kargi et al. 2003).

Various methodologies and classification criteria have been used in the assessment of vision/visual acuity (Table 3). Bist et al. (2011), for example, assessed vision and visual acuity with a Snellen tumbler ‘E’ test chart, which do not require literacy. Whilst most research has used traditional Snellen charts at 6 m, there has been little use of log MAR assessment despite it being acknowledged as a superior measurement (Lovie-Kitchin 2008). Visual acuity of young children has been assessed with a variety of tests including Sheridan Gardiner cards, Kay pictures, Lea Crowded Symbols (near vision) and for preverbal children, Cardiff preferential looking cards (Armitage et al. 1995; Guy et al. 2003). Crowded Kay pictures and Lea pictures are considered the most appropriate tests for young children with the LogMAR crowded acuity test and the Sonsken Log MAR chart being the tests of choice for children over 3 years (Saunders 2010). The reliance on Snellen charts as compared to the Log MAR system may be at least in part due to the location and the clinical nature of the majority of studies where Snellen charts are more commonly available.

Near vision assessments in deaf individuals are a rarity within the literature and when they have been undertaken, the reduced Snellen tumbler ‘E’ letter charts have typically been used (Regenbogen & Godel 1985). For example, Hanioglu-Kargi et al. (2003) assessed with a Snellen reduced E near chart and Khandekar et al. (2009) with near Lea symbols. Although measurement of near vision was undertaken by Khandekar et al. (2009), no near vision results were presented. It is evident that many of the deaf studies from developing countries (Gogate et al. 2009; Khandekar et al. 2009; Abah et al. 2011) have greater reliance on non-reading ‘illiterate’ tests possibly indicating the greater difficulties these children have in acquiring basic reading skills when compared with their hearing counterparts or simply that the levels of literacy are much lower in these countries.

Refractive errors have often been assessed objectively using retinoscopy both with, (Mohindra 1976; Regenbogen & Godel 1985; Leguire et al. 1992; Siatkowski et al. 1993) and without cycloplegia. Evidence of subjective non-cycloplegic refractions having been performed is limited. Cycloplegic refractions are the most accurate method of assessing refraction for children because of the control of accommodative effort (Fotouhi et al. 2012). Inclusion criteria for refractive errors have considerable variation. For example, Guy et al. (2003) set inclusion for spherical ametropia at ≥±2.0 D (dioptres) whilst Armitage et al. (1995) included hyperopia of ≥±1.50 D without esotropia (≥±3.00 D without esotropia). Outlined below are a few of the most commonly observed refractive and binocular vision abnormalities as documented in deaf individuals.

Hyperopia

Hyperopic ametropia associated with deafness is the most commonly reported refractive error (Alexander 1973; Mohindra 1976; Regenbogen & Godel 1985; Siatkowski et al. 1993; Armitage et al. 1995; Abah et al. 2011) with the prevalence varying between 8% (≥±2.25 D; Pollard & Neumaier 1974 – non-cycloplegic refraction) and 31.5% (≥±2.50 D; Siatkowski et al. 1993; cycloplegic refraction) as compared to between 4% (≥±2.00 D; Fan et al. 2004) and 12.8% (≥±1.25 D; Kleinste et al. 2003) in a normal hearing population for cycloplegic refractions and 7.7% (≥±1.50 D; Junghans et al. 2002) for non-cycloplegic refractions.

Table 3. Selection of deaf studies showing variation in criteria used to classify visual defects

<table>
<thead>
<tr>
<th>Studies</th>
<th>Number of participants</th>
<th>Hyperopia (D)</th>
<th>Myopia (D)</th>
<th>Astigmatism (D)</th>
<th>Anisometropia</th>
<th>Amblyopia</th>
<th>Near vision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollard &amp; Neumaier</td>
<td>511</td>
<td>≥2.25</td>
<td>≥0.75</td>
<td>&gt;1.25</td>
<td>≥1.25</td>
<td>≤6/12</td>
<td>(20/40)</td>
</tr>
<tr>
<td>Leguire et al. 1992</td>
<td>505</td>
<td>≥2.00</td>
<td>≥1.00</td>
<td>≥1.00</td>
<td>≥1.00</td>
<td>≤6/9</td>
<td>(20/30)</td>
</tr>
<tr>
<td>Siatkowski et al. 1993</td>
<td>54</td>
<td>≥2.50</td>
<td>≥1.00</td>
<td>≥1.50</td>
<td>≥1.00</td>
<td>≤6/9</td>
<td>(20/30)</td>
</tr>
<tr>
<td>Armitage et al. 1995</td>
<td>83</td>
<td>≥3.00 (≥±1.50)</td>
<td>≥1.00</td>
<td>≥1.50</td>
<td>≥1.00</td>
<td>≤6/9</td>
<td>(20/30)</td>
</tr>
<tr>
<td>Guy et al. 2003</td>
<td>110</td>
<td>≥4.00</td>
<td>≥4.00</td>
<td>≥1.50</td>
<td>≥1.00</td>
<td>≤6/9</td>
<td>(20/30)</td>
</tr>
<tr>
<td>Hanioglu-Kargi et al. 2003</td>
<td>104</td>
<td>≥1.50</td>
<td>≥1.00</td>
<td>≥1.50</td>
<td>≥2.00</td>
<td>≤6/9</td>
<td>(20/30)</td>
</tr>
<tr>
<td>Gogate et al. 2009</td>
<td>901</td>
<td>≥2.00</td>
<td>≥0.50</td>
<td>≥0.50</td>
<td>*</td>
<td>≤6/60</td>
<td>(20/200)</td>
</tr>
<tr>
<td>Khandekar et al. 2009</td>
<td>223</td>
<td>≥4.00</td>
<td>≥1.00</td>
<td>1.25</td>
<td>*</td>
<td>≤6/60</td>
<td>(20/200)</td>
</tr>
</tbody>
</table>

* No data available.
† With esotropia.
‡ Without esotropia. D. dioptres.
Myopia

Myopia is the second most frequently reported visual defect. There is a greater prevalence of myopia in deaf and hearing-impaired individuals (Leguire et al. 1992) even when allowing for the increase in myopia with age (Coleman 1970; Saw et al. 2005). Estimates of the prevalence of myopia in the deaf have ranged from 6% (≥1.00 D; Hanioglu-Kargi et al. 2003) to 20.9% (>4.00 D; Guy et al. 2003).

Astigmatism

There appears to be a greater prevalence of astigmatism in the deaf and hearing-impaired, with Pollard & Neumaier (1974) reporting 7.3% in their deaf participants compared with 1.4% in their group of hearing children. Compared with other visual defects, studies have shown far greater agreement with criteria for astigmatism, ranging from ≥1.00 D to ≥1.50 D (Pollard & Neumaier 1974; Siatkowski et al. 1993; Armitage et al. 1995; Guy et al. 2003), although Hanioglu-Kargi et al. (2003) used a ≥2.00 D criterion and reported prevalence in the deaf of 14.4%. Woodruff (1986) in his retrospective study suggested that higher levels of astigmatism (>1.00 D) may be associated with congenital rubella, although no associations with disease process or level of deafness have been suggested elsewhere. Mohindra (1976) subdivided her astigmatic participants into ‘with-the-rule’ (steeper corneal curvature vertically) and ‘against-the-rule’ (steeper curvature horizontally). Corneal curvature was measured using keratometry, and there were twice the number of ‘with-the-rule’ astigmats than ‘against-the-rule’, although no relationship to deafness was described. A higher prevalence of with-the-rule astigmatism is in accordance with studies in a normal population (Khabazkhoob et al. 2010). Woodruff (1986) also reviewed corneal curvature suggesting congenital rubella subjects show greater curvature and a high prevalence of microphthalmia.

Amblyopia

A greater prevalence of amblyopia has consistently been shown in the deaf, with criteria ranging from <6/9 (20/30) (Hanioglu-Kargi et al. 2003) to <6/60 (20/200) (Gogate et al. 2009) and prevalence ranging between 4.4% (Leguire et al. 1992) and 14.4% (Hanioglu-Kargi et al. 2003). The increased occurrence of amblyopia has variously been attributed to ocular pathology, strabismus, cataracts and anisometropia.

Anisometropia

Anisometropia also has an increased prevalence in the deaf. Definitions of anisometropia have been extremely variable. For example, Pollard & Neumaier (1974) set a criterion of 1.25 D difference between eyes whilst Hanioglu-Kargi et al. (2003) used ≥2.00 D and Regenbogen & Godel (1985) ≥3.00 D.

Binocular vision abnormalities

Strabismus (heterotropia) and heterophoria have commonly been measured with a simple cover/uncover test (Suchman 1967; Guy et al. 2003). Heterophoria has occasionally been quantified using an alternating cover test in association with a prism bar, although few studies have reported the magnitude of phoria. Alexander (1973) used a cover/uncover prism test and Maddox rod to quantify the heterophoria. Whilst these tests were stated in the methods, only strabismic anomalies were published in the results. Alexander found 11% of 572 deaf children with strabismus, 16 children having accommodative esotropia with a further 29 being non-accommodative. Mohindra (1976) used the cover test for distance and near, reporting results for the distance cover test only for a prevalence of 9% strabismus and 10% heterophoria. Deviations of >10 prism dioptries have been considered significant (Leguire et al. 1992; Hanioglu-Kargi et al. 2003) and have been reported as more common in deaf cohorts compared with normal hearing cohorts. Regenbogen & Godel (1985) found a prevalence of 4.6% compared with 1.8% in a normal hearing population whilst Pollard & Neumaier (1974) found no difference with strabismus in 4.9% of their deaf participants compared with 4.8% in a hearing group, although the criteria in their hearing group was ‘less rigid’. Accommodation and associated phoria (fixation disparity) have not featured in the reviewed papers. These assessments would give a greater insight into the co-ordination of the eyes, which is especially important with near vision.

Stereopsis

Stereopsis has been measured in early studies using the wings of a toy butterfly and more recently with the Titmus stereo fly, Wirt dot (Mohindra 1976) and TNO tests (Hanioglu-Kargi et al. 2003). Normal stereo acuity has been set at ≤100 seconds of arc for the majority of studies. Mohindra (1976), using the stereo fly and Wirt dot tests, found over 32% of the deaf participants with a stereopsis of >100 seconds of arc. Reduced stereopsis is associated with refractive error and/or an ocular motor abnormality that is in accordance with the greater prevalence of strabismus (Alexander 1973) and amblyopia (Hanioglu-Kargi et al. 2003) in deaf children.

Contrast sensitivity (CS)

Ushers syndrome is associated with deafness and retinitis pigmentosa, and in the only study to have assessed contrast sensitivity, a deficit was shown (Hartong et al. 2006).

Colour vision

Colour vision has been assessed with the Ishihara Colour Test (Mohindra 1976; Regenbogen & Godel 1985), D15 Test (Khandekar et al. 2009) and Farnsworth–Munsell 100-Hue Test (Mohindra 1976). Mohindra (1976) found 2.1% of females (N = 43) and 6.9% of males (N = 29) to have colour defects using Ishihara and Farnsworth 100-Hue tests. These levels are consistent with larger scale normative studies and would suggest little variation in the prevalence of colour defects in the deaf (Birch & Platts 1993).

As the research outlined above clearly shows, the prevalence of hyperopia, myopia, astigmatism and binocular anomalies is increased in deaf individuals, irrespective of whether the deafness is congenital or acquired, severe or mild.

Range and severity of hearing impairment and visual performance

Early studies qualitatively grouped deafness into broad levels of moderate, severe and profound (Suchman 1967), whilst later studies have attempted a quantitative assessment of hearing loss.
Ocular abnormalities

The retina and the cochlea structures are formed at the same developmental stage and embryonic layer, so any pathological defect within these areas could lead to oculo-auditory defects (Armitage et al. 1995; Nikolopoulos et al. 2006). There is little consensus in the literature regarding which diseases should be considered for inclusion in deaf vision studies with generic terms such as ‘hereditary’ and ‘acquired’ conditions being the most commonly reported. Some early studies such as that by Suchman (1967) have examined the external eye and observed the red reflex of the fundus giving little information of posterior segment pathology. Other studies (e.g., Guy et al. 2003) assessed pathological abnormalities in greater detail, having categorized the pathologies into genetic syndromal, autosomal recessive, autosomal dominant, infective, metabolic, acquired and unknown causes. Sixty-three of the 122 children in the study by Guy et al. (2003) had a genetic cause of their deafness; 13 were linked to known oculoauditory syndromes such asusher’s syndrome, Leigh’s encephalopathy and Wildervanck’s syndrome, and 45 had an unknown cause. This greater detail has given better insight into the associations between deafness, vision and the disease processes, enabling better identification of individuals who may be at risk from these disease processes, whether genetic or acquired, and allowing treatment at an earlier stage of development. In comparison, Regenbogen & Godel (1985) grouped the pathological conditions into broader areas: fundus, macular, external, pupillary retinal changes, retinitis pigmentosa and optic disc atrophy but without relating the findings to any specific syndrome.

A diverse range of diseases has been related to deafness and vision defects, and many of these diseases are very rare. Woodruff (1986) reviewed the case histories of 420 children attending schools for the deaf in Ontario, reported congenital rubella as the most significant pathology and highlighted its association with an increased prevalence of strabismus and amblyopia, secondary to retinopathy and cataracts. Other studies have also found ocular pathologies associated with rubella (Mohindra 1976; Leguire et al. 1992; Mitchell et al. 2001). Fortunately, congenital rubella is now a relatively infrequent cause of deafness particularly within developed countries (Nikolopoulos et al. 2006). Consequently, it is now more common to attribute deafness and visual problems to genetic causes and the more prevalent infective problems, for example cytomegalovirus, toxoplasmosis and syphilis (Guy et al. 2003; Nikolopoulos et al. 2006). Unfortunately, ‘unknown aetiology’ is by far the largest pathological category in much of the research. Nikolopoulos et al. (2006) reviewed in detail the ophthalmological abnormalities associated with deafness, and readers are referred to this paper for a full review.

In conclusion, it is now well established that associations between deafness, ocular pathology and visual performance exist. Assessment of deaf children’s vision should always consider ocular abnormalities, together with the refractive and binocular status.

Communication and near vision

Visual defects in the deaf are particularly important due to the social and educational ramifications of having a dual disability (Dammeyer 2010). The possible effects of visual defects on communication skills have not been adequately researched, although it has been well established that deaf children have difficulties in reading and lag behind their hearing peers (Musselman 2000; Perfetti & Sandak 2000; Goldin-Meadow & Mayberry 2001). This developmental delay has often been attributed to a lack of phonic awareness of the words, making comprehension problematic. Surprisingly, there has been relatively little assessment of the levels of near vision function and binocular co-ordination in these children: visual defects appear to have simply not been considered relevant. Indeed, there are a variety of proposed methods in the literature for reading acquisition in deaf children with a large proportion dedicated to phonic defects. Less attention has been given to logarithraphic and orthographic (visual) routes to reading (Booth et al. 2000; Perfetti & Sandak 2000). Whilst phonic understanding of words would appear...
essential for reading, visual recognition of the words is the starting point for any reading task. Therefore, any functional near visual impairment may impede this development.

Conclusion

Research over the past 70 years has established a strong relationship between deafness and ocular abnormalities. Most studies have (almost) exclusively investigated distance vision and have shown higher levels of dysfunction in the deaf when compared with normal hearing groups. Near vision is especially important when considering the altruistic objective of enhancing social and educational abilities but has received little study even though it is essential for the acquisition of knowledge via sign language, lip reading, facial gestures, reading text, figures or pictorially.

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Received on October 23rd, 2012.

Accepted on September 19th, 2013.

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<td>4</td>
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<td>5</td>
<td>AUTHOR: Alexander et al. 1973 has been changed to Alexander 1973 so that this citation matches the Reference List. Please confirm that this is correct.</td>
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<td>6</td>
<td>AUTHOR: Pollard et al. 1974 has been changed to Pollard and Neumaier 1974 so that this citation matches the Reference List. Please confirm that this is correct.</td>
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<td>7</td>
<td>AUTHOR: Regenbogen 1985 has been changed to Regenbogen and Godel 1985 so that this citation matches the Reference List. Please confirm that this is correct.</td>
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<td>8</td>
<td>AUTHOR: Siatkowski et al. 1994 has been changed to Siatkowski et al. 1993 so that this citation matches the Reference List. Please confirm that this is correct.</td>
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<td>9</td>
<td>AUTHOR: Brinks et al. 2001 has not been included in the Reference List, please supply full publication details.</td>
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<td>10</td>
<td>AUTHOR: Bist et al. 2010 has been changed to Bist et al. 2011 so that this citation matches the Reference List. Please confirm that this is correct.</td>
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<td>11</td>
<td>AUTHOR: Regenbogen &amp; Golden 1985 has been changed to Regenbogen and Godel 1985 so that this citation matches the Reference List. Please confirm that this is correct.</td>
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<td>12</td>
<td>AUTHOR: Pollard et al., 1974 has been changed to Pollard and Neumaier 1974 so that this citation matches the Reference List. Please confirm that this is correct.</td>
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<td>13</td>
<td>AUTHOR: Siatkowski et al., 1994 has been changed to Siatkowski et al. 1993 so that this citation matches the Reference List. Please confirm that this is correct.</td>
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<td>14</td>
<td>AUTHOR: Khadehar et al. (2009) has been changed to Khandekar et al. (2009) so that this citation matches the Reference List. Please confirm that this is correct.</td>
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<td>15</td>
<td>AUTHOR: Hanioglou-Karg et al. (2003) has been changed to Hanioglou-Karg et al. (2003) so that this citation matches the Reference List. Please confirm that this is correct.</td>
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<td>16</td>
<td>AUTHOR: Regenbogen &amp; Godel 1974; has been changed to Regenbogen and Godel 1985 so that this citation matches the Reference List. Please confirm that this is correct.</td>
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<td>17</td>
<td>AUTHOR: Nikololopoulos et al., (2006) has been changed to Nikolopoulos et al. (2006) so that this citation matches the Reference List. Please confirm that this is correct.</td>
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Please provide the publisher location for reference British Society of Audiology (2004).
USING e-ANNOTATION TOOLS FOR ELECTRONIC PROOF CORRECTION

Required software to e-Annotate PDFs: Adobe Acrobat Professional or Adobe Reader (version 8.0 or above). (Note that this document uses screenshots from Adobe Reader X)
The latest version of Acrobat Reader can be downloaded for free at: [http://get.adobe.com/reader/](http://get.adobe.com/reader/)

Once you have Acrobat Reader open on your computer, click on the Comment tab at the right of the toolbar:

This will open up a panel down the right side of the document. The majority of tools you will use for annotating your proof will be in the Annotations section, pictured opposite. We’ve picked out some of these tools below:

1. **Replace (Ins) Tool** – for replacing text.
   - Strikethrough (Del) Tool – for deleting text.

   How to use it
   - Highlight a word or sentence.
   - Click on the Replace (Ins) icon in the Annotations section.
   - Type the replacement text into the blue box that appears.

   How to use it
   - Highlight a word or sentence.
   - Click on the Strikethrough (Del) icon in the Annotations section.

2. **Add note to text Tool** – for highlighting a section to be changed to bold or italic.

   How to use it
   - Highlight the relevant section of text.
   - Click on the Add note to text icon in the Annotations section.
   - Type instruction on what should be changed regarding the text into the yellow box that appears.

3. **Add sticky note Tool** – for making notes at specific points in the text.

   How to use it
   - Click on the Add sticky note icon in the Annotations section.
   - Click at the point in the proof where the comment should be inserted.
   - Type the comment into the yellow box that appears.
5. **Attach File Tool** – for inserting large amounts of text or replacement figures.

**How to use it**
- Click on the **Attach File** icon in the Annotations section.
- Click on the proof to where you’d like the attached file to be linked.
- Select the file to be attached from your computer or network.
- Select the colour and type of icon that will appear in the proof. Click OK.

6. **Add stamp Tool** – for approving a proof if no corrections are required.

**How to use it**
- Click on the **Add stamp** icon in the Annotations section.
- Select the stamp you want to use. (The **Approved** stamp is usually available directly in the menu that appears).
- Click on the proof where you’d like the stamp to appear. (Where a proof is to be approved as it is, this would normally be on the first page).

7. **Drawing Markups Tools** – for drawing shapes, lines and freeform annotations on proofs and commenting on these marks.

**How to use it**
- Click on one of the shapes in the **Drawing Markups** section.
- Click on the proof at the relevant point and draw the selected shape with the cursor.
- To add a comment to the drawn shape, move the cursor over the shape until an arrowhead appears.
- Double click on the shape and type any text in the red box that appears.

For further information on how to annotate proofs, click on the **Help** menu to reveal a list of further options: