



Visual Efficiency Skills - Origins and Effects on Visual Perception: a Review of the Literature

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Abstract:

A review of the literature details the risk factors associated with visual efficiency problems, and the link between visual efficiency, visual perception and information processing. The current literature clearly shows there is evidence linking the above, as well as showing that by managing visual efficiency we can improve the potential to further develop our visual processing capacity. The current literature also demonstrates there is still a need for more epidemiological studies as well as developing controlled studies to investigate the impact visual efficiency problems have on our capacity to process visual information.

Introduction

Clinically, we often see how important visual efficiency skills are in ensuring optimal performance and integration of the visual system with the rest of our sensory motor pathways. The impact a visual efficiency problem can have on learning and potential in the classroom can sometimes be significant. Determining risk factors affecting visual efficiency is the first step towards developing a management plan.

Scheiman and Rouse¹ discuss visual efficiency problems as due to:

- Accommodative vergence dysfunction
- Oculomotor dysfunction



- Uncorrected refraction.

Visual Efficiency and Accommodation-Vergence Skills

Fatigue/stress influences accommodative vergence skills and may induce accommodative vergence dysfunction: for example, accommodative insufficiency (AI), accommodative excess (AE), convergence insufficiency (CI), convergence excess (CE).

Genetic predisposition will also influence manifestations of accommodative vergence dysfunction eg. CI, CE, divergence excess (DE) or divergence insufficiency (DI).

Uncorrected refractive error can induce accommodative-vergence disorders eg. CE, basic esophoria, AI or other accommodative vergence disorders.

Visual Efficiency and Oculomotor Skills

Smooth pursuit, saccadic eye movements and fixation stability are complex actions which are influenced by multiple control centres in the brain. Development of these skills for various tasks can be affected by stress/fatigue, environmental and genetic factors.

Smooth pursuit movements are controlled by magnocellular pathway function. Smooth pursuit skills reflect attentional capability.

Numerous cortical areas are involved in the generation of saccadic eye movements. Saccadic eye movements are initiated by the frontal and parietal lobes and are influenced by attention.

Visual Efficiency and Uncorrected Refractive Error

Genetic – environmental factors influence development of refractive error.

Uncorrected refractive error, in particular hyperopia and astigmatism, will influence visual efficiency, creating secondary accommodative-vergence and/or oculomotor disorders.



Visual Efficiency and Visual Perception

- Does a visual efficiency problem influence visual perception?
- Is visual processing and effectiveness of learning affected in any way by visual efficiency?

A literature search over the last 25 years regarding links between learning, educational performance, reading and vision produced many conflicting papers.

Young et al³ reported on testing 25 visual factors (where they did not know the reading ability of child) of 144 students (grade 1 and 2) in Texas, and showed visual efficiency and accommodative vergence problems were much greater in non-readers than in readers.

Birnbaum⁴ detailed the clinical implications of near point visual stress, stating that early identification and initiation of treatment for near point stress (NPS) is important, as NPS may cause discomfort and interfere with academic and vocational achievement by limiting potential, causing adaptations and avoidance of near tasks.

Rosner and Gruber⁵ showed that hyperopes of school age were more likely to manifest lags in the development of visual perceptual skills compared to emmetropes and myopes of equivalent age.

Rosner and Rosner⁶ demonstrated that hyperopes treated by 4 years of age have better visual perceptual skills than those treated after age 4 years.

Rosner and Rosner⁷ compared refractive status, visual acuity, binocular vision status, accommodation and vergence, and perceptual skills in children with learning difficulties (LD) and no LD and found hyperopia and perceptual skills dysfunction were more prevalent in children with LD.

Ludlam and Ludlam⁸ studied optometry students who were provided with material to read with questions at the end of the reading passage. Some were given plano glasses,



and some were given base in prism glasses (inducing an eso profile, requiring divergence to fuse). They found reading comprehension was significantly lower in the 'base in' group relative to the 'control' group. This effect was shown to be greater with longer passages.

Borsting⁹ compared three types of visual attentional ability in children with and without accommodative vergence dysfunctions; the subjects were aged 8 to 11 years, with normal intelligence. The group with accommodative/vergence dysfunction performed significantly poorer in two of the three types of tasks given. This supports the concept that some visual attentional skills are influenced by accommodative/vergence skills.

Kulp and Schmidt¹⁰ concluded that efficient reading requires accurate eye movements and continuous integration of information obtained from each fixation by the brain.

What does the ophthalmological literature tell us about the effectiveness of Vision Therapy?

Sterner, Abrahamsson and Sjöström¹¹ showed VT for patients with accommodative infacility improved symptoms and signs even two years after treatment.

Abdi and Rydberg¹² showed that in school children with AI, CI, refractive error or latent strabismus, corrective lenses helped 98% of cases and VT helped 100% of CI cases.

Rawstron, Burley and Elder¹³ in a review paper examined the current scientific evidence base regarding the efficacy of eye exercises in optometric vision therapy. They concluded VT for CI, ABI, amblyopia and improving stereopsis was beneficial. The rest is still controversial!

Motsch and Muhlendyck¹⁴ studied a group of patients with a diagnosis of dyslexia who were shown to have ocular disturbances (accommodative, uncorrected hyperopia, exophoria) in 85% of the group; 78% showed an improvement in reading after therapy



treatment. They concluded that the results underline the importance of correction of even small refraction and/or motility errors in the presence of reading or writing difficulties.

Kapoula, Bucci, Jurion, Ayoun, Afkhami, Brémond-Gignac¹⁵ made an orthoptic evaluation of 57 dyslexic and 46 non dyslexic age matched children. Of the dyslexic group, stereopsis was comparable to non dyslexics. Remote near point of convergence (NPC) and “divergence deficits” were found in the dyslexic group relative to the non dyslexic group. They concluded that vergence deficits are frequently present in dyslexics and that dyslexics should be given therapy to address these deficits.

Palomo-Alvarez and Puell¹⁶ conducted a cross sectional study of 87 poor readers and 32 control children (8 to 13 years) in Spain. They investigated accommodative function and facility and found both monocular and binocular accommodative function was significantly reduced in the poor reader group relative to the control group.

Kapoula and Bucci¹⁷ showed postural instability in dyslexics could be due to oculomotor deficits in these groups.

Bucci, Brémond-Gignac and, Kapoula¹⁸ showed that dyslexic children have poor binocular coordination during and after saccadic eye movements, implying an oculomotor deficiency in these children.

Hoffman, Girshick, Akeley and Banks¹⁹ studied the influence of accommodative vergence on binocular fusion, space perception and visual fatigue, and the effects on electronic 3D displays. They showed that when accommodation vergence coupling was compromised, the time required to identify a stereoscopic stimulus, stereo acuity, fatigue and discomfort were all affected negatively.

Bharadwaj and Candy²⁰ showed monocular viewing gave less accommodative gain than binocular viewing of the same targets. Binocular viewing appears necessary and ensures optimal accommodative vergence response in normal individuals.



O'Leary and Evans²¹ showed that correcting heterophoria improved visual performance in both non-symptomatic and symptomatic patients. They then concluded that managing a heterophoria with lenses or VT should help as well.

Gallaway and Boas²² investigated six children with symptomatic accommodative/vergence problems, provided VT, and measured reading and eye movement skills before and after VT. All children showed clinically significant improvements in reading speed and eye movement efficiency.

Borsting, Rouse and Chu²³ studied children selected with Accommodative Dysfunction/CI, and previously diagnosed with LD or ADHD. They tested for ADHD/cognitive problem/inattention using an indexing form and showed the score was significantly different to normative data in this group of children, indicating a higher frequency of such behaviours in children with visual efficiency issues.

Roch-Levecq, Brody, Thomas and Brown²⁴ longitudinally studied 70 children (3-5yrs), comprised of 35 with uncorrected ametropia (bilateral hyperopia of 4 dioptres or greater, astigmatism of 2 dioptres or more in children 3 yrs and 1.5 dioptres of more in children aged 4-5 yrs or a combination of both), and 35 emmetropes (2 dioptres of sphere or less and 1 dioptre or less of astigmatism). The Beery-Buktenica Developmental Test of Visual-Motor Integration (VMI) and Wechsler Preschool and Primary Scale of Intelligence-Revised (WPPSI) were undertaken pre-and post-correction. Both test scores were significantly poorer in the uncorrected group relative to the control group. VMI scores improved significantly in the ametropic group once corrected, relative to the control group at 6 weeks' review.

Garzia, Nicholson, Gaines, Murphy, Kramer and Potts²⁵ simulated binocular near stress with -2.00D lenses. They showed performance, as determined by time to complete a task,



was significantly reduced with -2.00D lenses relative to no lenses using 3rd yr optometry students.

*Referring to the American Academy of Optometry & American Optometric Association Policy Statement:*²⁶

- Vision problems can and do interfere with learning
- People at risk for learning related vision problems should be evaluated by an optometrist who provides services in this area.
- The goal of optometric intervention is to improve visual function and alleviate signs and symptoms.
- Prompt remediation of learning related vision problems enhances the ability of children and adults to perform to full potential.
- People with learning problems require help from many disciplines to meet the learning challenges they face. Optometric involvement constitutes one aspect of a multidisciplinary approach to prepare the individual for lifelong learning.

*From the American Optometric Association National Guidelines for care of the patient with accommodative vergence dysfunction*²⁷

The general goals for treating accommodative and/or vergence dysfunction are:

- To assist the patient to function efficiently in school performance, at work and/or in athletic activities.
- To relieve ocular, physical and psychological symptoms associated with these disorders.
- The guidelines list the specific dysfunction with ideal treatment plans and duration of therapy recommended, including a prognosis for each condition. Guidelines are



reviewed biannually and a search of the literature is undertaken and reviewed to ensure guidelines are kept up to date.

- Careful communication of visual disorders to other professionals.

Finally, Scheiman and Rouse¹ state:

“Vision problems contribute to reading disability but do NOT cause it”

“Visual Efficiency problems at a critical period of reading development will add to and increase the risk of reading disability”.

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