Research update on Visually-Based Reading Disability

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A. Effect of Vision Therapy on Reading Performance

1. Effect of attention therapy on reading comprehension.

Solan HA, Shelley-Tremblay J, Ficarra A, Silverman M, Larson S.
J Learn Disabil. 2003 Nov-Dec;36(6):556-63.
State College of Optometry, State University of New York, New York, NY 10036, USA. hsolan@sunyopt.edu

Abstract

This study quantified the influence of visual attention therapy on the reading comprehension of Grade 6 children with moderate reading disabilities (RD) in the absence of specific reading remediation. Thirty students with below-average reading scores were identified using standardized reading comprehension tests. Fifteen children were placed randomly in the experimental group and 15 in the control group. The Attention Battery of the Cognitive Assessment System was administered to all participants. The experimental group received 12 one-hour sessions of individually monitored, computer-based attention therapy programs; the control group received no therapy during their 12-week period. Each group was retested on attention and reading comprehension measures. In order to stimulate selective and sustained visual attention, the vision therapy stressed various aspects of arousal, activation, and vigilance. At the completion of attention therapy, the mean standard attention and reading comprehension scores of the experimental group had improved significantly. The control group, however, showed no significant improvement in reading comprehension scores after 12 weeks. Although uncertainties still exist, this investigation supports the notion that visual attention is malleable and that attention therapy has a significant effect on reading comprehension in this often neglected population

2. M-cell deficit and reading disability: a preliminary study of the effects of temporal vision-processing therapy.

Solan HA, Shelley-Tremblay J, Hansen PC, Silverman ME, Larson S, Ficarra A.
Optometry. 2004 Oct;75(10):640-50.
Schnurmacher Institute for Vision Research, State University of New York, State College of Optometry, New York, New York 10036, USA. hsolan@sunyopt.edu

Abstract

BACKGROUND: This study examines the following questions: In moderately disabled readers, will temporal vision-processing therapy procedures that benefit reading comprehension, visual attention, and oculomotor skills ameliorate M-cell processing deficits as measured with coherent motion threshold testing? And will the results show a corresponding improvement in oral reading and verbal skills? METHOD: A sample of 16 moderately disabled readers, evaluated in a study completed 6 months earlier, were retested with another form of the Gates-MacGinitie Reading Test. Each participant was additionally tested for coherent motion, oral reading, and word attack skills. During the succeeding 6 months, fifteen 45-minute therapy sessions were administered once a week (as the school schedule permitted). After completing 15 therapy sessions, the initial testing procedures were repeated. RESULTS: All four variables--namely, Gates-MacGinitie Reading Test, Coherent Motion Threshold Test, Gray Oral Reading Test, and Woodcock-Johnson Word Attack Test--revealed significant improvements after temporal vision therapy. Half of the 16 participants improved 2 or more years in reading comprehension, compared to no significant mean difference following the 6-month "control period" before the onset of therapy. CONCLUSIONS: This research supports the value of rendering temporal vision therapy to children identified as moderately reading disabled (RD). The diagnostic procedures and

the dynamic therapeutic techniques discussed in this article have not been previously used for the specific purpose of ameliorating an M-cell deficit. Improved temporal visual-processing skills and enhanced visual motion discrimination appear to have a salutary effect on magnocellular processing and reading comprehension in RD children with M-cell deficits.

3. Role of visual attention in cognitive control of oculomotor readiness in students with reading disabilities.

Solan HA, Larson S, Shelley-Tremblay J, Ficarra A, Silverman M.
J Learn Disabil. 2001 Mar-Apr;34(2):107-18.
State College of Optometry, State University of New York, New York 10010, USA. hsolan@sunyopt.edu

Abstract

This study investigated eye movement and comprehension therapy in Grade 6 children with reading disabilities (RD). Both order of therapy and type of therapy were examined. Furthermore, the implications of visual attention in ameliorating reading disability are discussed. Thirty-one students with RD were identified using standardized reading comprehension tests. Eye movements were analyzed objectively using an infra-red recording device. Reading scores of participating children were 0.5 to 1 SD below the national mean. Testing took place before the start of therapy (T1) and was repeated after 12 weeks (T2) and 24 weeks (T3) of therapy. One group of students had eye movement therapy first, followed by comprehension therapy; in the other group, the order was reversed. Data were evaluated using a repeated measures MANOVA and post hoc tests. At T1, mean reading grade was 2 years below grade level, and eye movement scores were at about Grade 2 level. Mean growth in reading comprehension for the total sample was 2.6 years ($p < .01$) at T3; equally significant improvement was measured in eye movements ($p < .01$). Learning rate in reading comprehension improved from 60% (T1) to 400% (T3). Although within-group differences were statistically significant, between-group differences were not significant for comprehension or eye movements. Order of therapy (comprehension first or eye movements first) was not significant. Improvements in within-group scores for comprehension and eye movements were consistently significant at T2 and T3. Eye movement therapy improved eye movements and also resulted in significant gains in reading comprehension. Comprehension therapy likewise produced improvement both in eye movement efficiency and in reading comprehension. The results support the notion of a cognitive link among visual attention, oculomotor readiness, and reading comprehension.

4. The Impact of Vergence and Accommodative Therapy on Reading Eye Movements and Reading Speed

Gallaway M, Boas, M
OptomVisDev. 2007 Vol 38(3):115-20

ABSTRACT

Background: Most studies investigating the impact of optometric vision therapy on reading speed and reading eye movements utilize ocular motility and visual processing procedures. Only one study has reported the impact of accommodative and vergence therapy alone on reading speed, but only with three subjects. **Methods:** Six patients with symptomatic accommodative/vergence anomalies received vision therapy along with objective eye movement recordings before and after therapy. Therapy consisted of procedures to treat accommodative and vergence skills – no saccadic or ocular motor procedures were utilized. **Results:** Each of the patients showed clinically significant improvements in reading speed and eye movement efficiency. **Conclusions:** Accommodative and vergence therapy alone has the potential to improve reading speed and reading eye movements. Ocular motor therapy may not be necessary for some patients with accommodative/vergence disorders who also demonstrate reduced reading speed and poor reading eye movements.

5. Training Direction-Discrimination Sensitivity Remediates a Wide Spectrum of Reading Skills

Lawton, T

OptomVisDev. 2007 Vol 38(1):37-51

ABSTRACT

Background: This study investigated whether timing deficits in the motion pathways represent a core deficit in inefficient readers who are dyslexic. **Methods**: Inefficient and efficient readers in grades 2 and 3 in four public elementary schools were studied. Component literacy skills were measured before and after training. In the training task of interest, participants judged the direction of motion (left vs. right) of a vertically oriented sinusoidal grating, surrounded by one of five different background frequencies. The threshold contrast for direction discrimination was measured. **Results:** Direction discrimination improved the most for inefficient readers following training. Moreover, following training the time to complete the task decreased significantly, showing that the timing of direction discrimination improves, as does the gain. For inefficient readers, training on direction discrimination resulted in significant improvements in reading efficiency and fluency. Inefficient readers in control conditions showed minimal improvement. **Conclusions:** Significant improvements in reading performance were found following training on direction discrimination. This study provides evidence that timing deficits in inefficient readers represent a core deficit.

6. A randomized prospective masked and matched comparative study of orthoptic treatment versus conventional reading tutoring treatment for reading disabilities in 62 children.

Atzmon D, Nemet P, et al.

Binocular Vision & Eye Muscle Surgery Quarterly, 8(2):p. 91-106, 1993.

Abstract: Controversies remain whether orthoptics and/or "visual training" can remedy reading disabilities. Therefore, and to extend our prior studies, we under took a comparative and controlled study. One hundred and twenty children with reading disability were tested extensively, matched and randomly divided into three groups: orthoptic, conventional (reading tutoring), and no-treatment control. Unfortunately, participants in the control group were unable to adhere to no-treatment and were deleted. Each of the 40 children in the first two groups had 40 sessions, 20 minutes daily. Orthoptic treatment was directed to markedly increasing fusional convergence amplitudes for both near and distance to 60 D. The two treatments were also carefully matched in time and effort. Sixty-two children in 31 matched pairs completed the course of treatment and testing. The results were equal and statistically significant (P< .05) marked improvement in reading performance in both treatment groups on essentially all tests. Orthoptic treatment, to increase convergence amplitudes to 60 D, is as effective as conventional in-school reading tutoring treatment of reading disabilities. An advantage of orthoptic treatment was that subjective reading and asthenopic symptoms (excessive tearing, itching, burning, visual fatigue, and headache) virtually disappeared after orthoptics. We recommend orthoptic treatment as: 1) an effective alternate primary treatment; 2) adjunctive treatment for those who do not respond well to standard treatment; and 3) as primary treatment in any case with asthenopic symptoms of /or convergence inadequacy.

7. Eye movement problems in achieving readers: an update.

Solan HA.
Am J Optom Physiol Opt. 1985 Dec;62(12):812-9

Abstract

There is extant a population of subjects who have average or better than average interpretive reading skills as measured by standardized tests but who read slowly and inefficiently. Ten cases are presented where both Iowa Silent Reading Tests (ISRT) (Level III) and eye movement recordings were completed. Three of the subjects received training to improve reading efficiency. Reducing the cognitive level of the reading selections did not result in improved reading efficiency for subjects who have good interpretive skills. Substantial improvement in reading efficiency was measured in each of the three subjects selected for training.

B. Vision Deficits in Reading Disability/Developmental Dyslexia

1. Visual control in children with developmental dyslexia.

Castro SM, Salgado CA, Andrade FP, Ciasca SM, Carvalho KM.
Arq Bras Oftalmol. 2008 Nov-Dec;71(6):837-40
Universidade Estadual de Campinas - Campinas (SP) - Brazil. stellamccastro@gmail.com

Abstract

PURPOSE: To assess binocular control in children with dyslexia. METHODS: Cross-sectional study with 26 children who were submitted to a set of ophthalmologic and visual tests. RESULTS: In the dyslexic children less eye movement control in voluntary convergence and unstable binocular fixation was observed. CONCLUSION: The results support the hypothesis that developmental dyslexia might present deficits which involve the magnocellular pathway and a part of the posterior cortical attentional network.

2. Two visual motion processing deficits in developmental dyslexia associated with different reading skills deficits.

Wilmer JB, Richardson AJ, Chen Y, Stein JF.
J Cogn Neurosci. 2004 May; 16(4):528-40
Harvard University, Cambridge, MA 02138, USA. wilmer@wjh.harvard.edu

Abstract

Developmental dyslexia is associated with deficits in the processing of visual motion stimuli, and some evidence suggests that these motion processing deficits are related to various reading subskills deficits. However, little is known about the mechanisms underlying such associations. This study lays a richer groundwork for exploration of such mechanisms by more comprehensively and rigorously characterizing the relationship between motion processing deficits and reading subskills deficits. Thirty-six adult participants, 19 of whom had a history of developmental dyslexia, completed a battery of visual, cognitive, and reading tests. This battery combined motion processing and reading subskills measures used across previous studies and added carefully matched visual processing control tasks. Results suggest that there are in fact two distinct motion processing deficits in developmental dyslexia, rather than one as assumed by previous research, and that each of these deficits is associated with a different type of reading subskills deficit. A deficit in detecting coherent motion is selectively associated with low accuracy on reading subskills tests, and a deficit in discriminating velocities is selectively associated with slow performance on these same tests. In addition, evidence from visual processing control tasks as well as self-reports of ADHD symptoms suggests that these motion processing deficits are specific to the domain of visual motion, and result neither from a broader visual deficit, nor from the sort of generalized attention deficit commonly comorbid with developmental dyslexia. Finally, dissociation between these two motion processing deficits suggests that they may have distinct neural and functional underpinnings. The two distinct patterns of motion processing and reading deficits demonstrated by this study may reflect separable underlying neurocognitive mechanisms of developmental dyslexia.

3. The magnocellular theory of developmental dyslexia.

Stein J.
Dyslexia. 2001 Jan-Mar;7(1):12-36
University Laboratory of Physiology, Oxford, UK.

Abstract

Low literacy is termed 'developmental dyslexia' when reading is significantly behind that expected from the intelligence quotient (IQ) in the presence of other symptoms--incoordination, left-right confusions, poor sequencing--that characterize it as a neurological syndrome. 5-10% of children, particularly boys, are found to be dyslexic. Reading requires the acquisition of good orthographic skills for recognising the visual form of words which allows one to access their meaning directly. It also requires the development of good phonological skills for sounding out unfamiliar words using knowledge of letter sound conversion rules. In the dyslexic brain, temporoparietal language areas on the two sides are symmetrical without the normal left-sided advantage. Also brain 'warts' (ectopias) are found particularly clustered round the left temporoparietal language areas. The visual magnocellular system is responsible for timing visual events when reading. It therefore signals any visual motion that occurs if unintended movements lead to images moving off the fovea ('retinal slip'). These signals are then used to bring the eyes back on target. Thus, sensitivity to visual motion seems to help determine how well orthographic skill can develop in both good and bad readers. In dyslexics, the development of the visual magnocellular system is impaired: development of the magnocellular layers of the dyslexic lateral geniculate nucleus (LGN) is abnormal; their motion sensitivity is reduced; many dyslexics show unsteady binocular fixation; hence poor visual localization, particularly on the left side (left neglect). Dyslexics' binocular instability and visual perceptual instability, therefore, can cause the letters they are trying to read to appear to move around and cross over each other. Hence, blanking one eye (monocular occlusion) can improve reading. Thus, good magnocellular function is essential for high motion sensitivity and stable binocular fixation, hence proper development of orthographic skills. Many dyslexics also have auditory/phonological problems. Distinguishing letter sounds depends on picking up the changes in sound frequency and amplitude that characterize them. Thus, high frequency (FM) and amplitude modulation (AM) sensitivity helps the development of good phonological skill, and low sensitivity impedes the acquisition of these skills. Thus dyslexics' sensitivity to FM and AM is significantly lower than that of good readers and this explains their problems with phonology. The cerebellum is the head ganglion of magnocellular systems; it contributes to binocular fixation and to inner speech for sounding out words, and it is clearly defective in dyslexics. Thus, there is evidence that most reading problems have a fundamental sensorimotor cause. But why do magnocellular systems fail to develop properly? There is a clear genetic basis for impaired development of magnocells throughout the brain. The best understood linkage is to the region of the Major Histocompatibility Complex (MHC) Class 1 on the short arm of chromosome 6 which helps to control the production of antibodies. The development of magnocells may be impaired by

autoantibodies affecting the developing brain. Magnocells also need high amounts of polyunsaturated fatty acids to preserve the membrane flexibility that permits the rapid conformational changes of channel proteins which underlie their transient sensitivity. But the genes that underlie magnocellular weakness would not be so common unless there were compensating advantages to dyslexia. In developmental dyslexics there may be heightened development of parvocellular systems that underlie their holistic, artistic, 'seeing the whole picture' and entrepreneurial talents.

4. Visual motion sensitivity and reading.

Stein J.
Neuropsychologia. 2003;41(13):1785-93
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Abstract

Reading is more difficult than speaking because an arbitrary set of visual symbols must be rapidly identified, ordered and translated into the sounds they represent. Many poor readers have particular problems with the rapid visual processing required for these tasks because they have a mild impairment of the visual magnocellular system. This deficit has been demonstrated using neuropathological, evoked potential, functional magnetic resonance imaging and psychophysical techniques. The sensitivity of the M-system in both good and bad readers correlates with their orthographic abilities, suggesting that the M-system plays an important part in their development. This role is probably to mediate steady direction of visual attention and eye fixations on words. Thus many children with reading difficulties have unsteady eye control and this causes the letters they are trying to read to appear to move around, so that they cannot tell what order they are meant to be in. Therefore, boosting M-performance using yellow filters, or training eye fixation, can improve reading performance very significantly. Several genetic linkage studies have associated reading difficulties with the MHC control region on the short arm of chromosome 6. This system has recently been shown to help regulate the differentiation of M-cells. This association could also explain the high incidence of autoimmune conditions in poor readers. Other chromosomal sites are associated with the metabolism of polyunsaturated fatty acids (PUFAs) as found in fish oils, and this could explain why PUFA supplements can improve reading.

5. Monocular occlusion can improve binocular control and reading in dyslexics.

Stein JF, Richardson AJ, Fowler MS.
Brain. 2000 Jan;123 (Pt 1):164-70
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Abstract

Developmental dyslexia is a neurodevelopmental condition which causes 5-10% of children to have unexpected difficulty learning to read. Many dyslexics have impaired development of the magnocellular component of the visual system, which is important for timing visual events and controlling eye movements. Poor control of eye movement may lead to unstable binocular fixation, and hence unsteady vision; this could explain why many dyslexics report that letters appear to move around, causing visual confusion. Previous research has suggested that such binocular confusion can be permanently alleviated by temporarily occluding one eye. The aim of the present study was therefore to assess the binocular control and reading progress of dyslexic children with initially unstable binocular control after the left eye was patched. One hundred and forty-three dyslexics were studied. They were selected from children aged 7-11 years referred to a learning disabilities clinic if they were dyslexic and had unstable binocular control. They were randomly assigned to wear yellow spectacles with or without the left lens occluded, and were followed for 9 months. Significantly more of the children who were given occlusion gained stable binocular fixation in the first 3 months (59%) compared with children given the unoccluded glasses (36%). This advantage was independent of IQ or initial reading ability. Furthermore, at all the 3-month follow-ups, children were more likely to have gained stable binocular control if they had been wearing the occluded glasses. Gaining stable binocular control significantly improved reading. The children who did so with the help of occlusion improved their reading by 9.4 months in the first 3 months, compared with 3.9 months in those who were not patched and did not gain stable fixation. Over the whole 9 months, children who received occlusion and gained stable fixation nearly doubled their rate of progress in reading compared with those who remained unstable. At all the follow-ups the reading of those given occlusion was significantly better than that of those not occluded. Thus monocular occlusion helped children with unstable binocular control to gain good binocular fixation. If they gained stability, they made significantly faster reading progress. The progress made by the children who gained stable fixation was much greater than that achieved with other remedial techniques.

6. Poor binocular coordination of saccades in dyslexic children.

Bucci MP, Brémond-Gignac D, Kapoula Z.
Graefes Arch Clin Exp Ophthalmol. 2008 Mar;246(3):417-28. Epub 2007 Nov 29
IRIS Group, CNRS, Service OPH-ORL-Stomatologie, Hôpital Européen Georges Pompidou & Pôle Chirurgie ORL-OPH, Hôpital Robert Debré, Paris, France. mariapia.bucci@gmail.com

Abstract

AIM: To examine the quality of binocular coordination of saccades in dyslexic children in single word reading and in a task requiring fixation of single LED. METHODS: Eighteen children with dyslexia (11.4 +/- 2 years old) and 13 non-dyslexic children of matched age were studied. Horizontal saccades from both eyes were recorded with a photoelectric system (Oculomotor-Bouis). RESULTS: Binocular coordination during and after the saccade in dyslexics is worse than that of non-dyslexic children; the disconjugacy does not depend on the condition. Moreover, dyslexics do not show the stereotyped pattern of disconjugacy (divergence during the saccade and convergence after the saccade). The conjugate post-saccadic drift is larger in dyslexics for both conditions. CONCLUSION: Poor quality of binocular coordination of saccades and drift of the eyes after the saccade, regardless of the task, indicates an intrinsic ocular motor deficiency. Such a deficiency could be related to immaturity of the normal ocular otor learning mechanisms via which ocular motor coordination and stable fixation are achieved. Learning could be based on the interaction between the saccade and vergence subsystems. The cerebellum, but also cortical areas of the magnocellular stream such as the parietal cortex, could be the sites of ocular motor learning.

7. Visually-based temporal distortion in dyslexia.

Johnston A, Bruno A, Watanabe J, Quansah B, Patel N, Dakin S, Nishida S.
Vision Res. 2008 Aug;48(17):1852-8. Epub 2008 Jun 26
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Abstract

In this study, we show that invisible flicker adaptation reduces the perceived duration of a subsequently viewed stimulus in control subjects, but not in dyslexics. Dyslexics, like controls, show apparent duration compression after 20Hz flicker and show normal shifts in apparent temporal frequency after adaptation. However a subgroup of the test group, scoring low on both a test of phonological skill (spoonerisms) and a test of literacy (NART), show an apparent temporal expansion after 5Hz flicker adaptation, a finding not previously seen in controls. Recent studies have linked genes conferring susceptibility to a cluster of language and sensory deficits to anomalous neural migration, providing a tentative biological basis for dyslexia. However it has proved difficult to establish a clear link between sensory deficits and impaired

reading. The results presented here point to an abnormal adaptation response within the early precortical stages of the magnocellular pathway, occurring in tandem with a deficit in word-level cognitive processing, providing psychophysical evidence for anomalous cortico-thalamic circuits in dyslexia.

8. The cognitive deficits responsible for developmental dyslexia: review of evidence for a selective visual attentional disorder.

Valdois S, Bosse ML, Tainturier MJ.
Dyslexia. 2004 Nov;10(4):339-63.
Laboratoire de Psychologie et Neuro-Cognition (UMR 5105 CNRS), Université Pierre Mendès France, Grenoble, France.
Sylviane.Valdois@upmf-grenoble.fr

Abstract

There is strong converging evidence suggesting that developmental dyslexia stems from a phonological processing deficit. However, this hypothesis has been challenged by the widely admitted heterogeneity of the dyslexic population, and by several reports of dyslexic individuals with no apparent phonological deficit. In this paper, we discuss the hypothesis that a phonological deficit may not be the only core deficit in developmental dyslexia and critically examine several alternative proposals. To establish that a given cognitive deficit is causally related to dyslexia, at least two conditions need to be fulfilled. First, the hypothesized deficit needs to be associated with developmental dyslexia independently of additional phonological deficits. Second, the hypothesized deficit must predict reading ability, on both empirical and theoretical grounds. While most current hypotheses fail to fulfill these criteria, we argue that the visual attentional deficit hypothesis does. Recent studies providing evidence for the independence of phonological and visual attentional deficits in developmental dyslexia are reviewed together with empirical data showing that phonological and visual attentional processing skills contribute independently to reading performance. A theoretical model of reading is outlined in support of a causal link between a visual attentional disorder and a failure in reading acquisition.

9. Developmental dyslexia: the visual attention span deficit hypothesis.

Bosse ML, Tainturier MJ, Valdois S.
Cognition. 2007 Aug;104(2):198-230. Epub 2006 Jul 21
Laboratoire de Psychologie et Neuro-Cognition (UMR 5105 CNRS), Université Pierre Mendès France, 1251 Ave Centrale BP 47, 38040 Grenoble Cedex 9, France.

Abstract

The visual attention (VA) span is defined as the amount of distinct visual elements which can be processed in parallel in a multi-element array. Both recent empirical data and theoretical accounts suggest that a VA span deficit might contribute to developmental dyslexia, independently of a phonological disorder. In this study, this hypothesis was assessed in two large samples of French and British dyslexic children whose performance was compared to that of chronological-age matched control children. Results of the French study show that the VA span capacities account for a substantial amount of unique variance in reading, as do phonological skills. The British study replicates this finding and further reveals that the contribution of the VA span to reading performance remains even after controlling IQ, verbal fluency, vocabulary and single letter identification skills, in addition to phoneme awareness. In both studies, most dyslexic children exhibit a selective phonological or VA span disorder. Overall, these findings support a multi-factorial view of developmental dyslexia. In many cases, developmental reading disorders do not seem to be due to phonological disorders. We propose that a VA span deficit is a likely alternative underlying cognitive deficit in dyslexia.

10. Dyslexia: a deficit in visuo-spatial attention, not in phonological processing.

Vidyasagar TR, Pammer K.
Trends Cogn Sci. 2010 Feb;14(2):57-63. Epub 2010 Jan 14
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Abstract

Developmental dyslexia affects up to 10 per cent of the population and it is important to understand its causes. It is widely assumed that phonological deficits, that is, deficits in how words are sounded out, cause the reading difficulties in dyslexia. However, there is emerging evidence that phonological problems and the reading impairment both arise from poor visual (i.e., orthographic) coding. We argue that attentional mechanisms controlled by the dorsal visual stream help in serial scanning of letters and any deficits in this process will cause a cascade of effects, including impairments in visual processing of graphemes, their translation into phonemes and the development of phonemic awareness. This view of dyslexia localizes the core deficit within the visual system and paves the way for new strategies for early diagnosis and treatment.

11. Coherent motion threshold measurements for M-cell deficit differ for above- and below-average readers.

Solan HA, Hansen PC, Shelley-Tremblay J, Ficarra A.
Optometry. 2003 Nov;74(11):727-34.
Schnurmacher Institute for Vision Research, College of Optometry, State University of New York, New York, New York 10036, USA. hsolan@sunyopt.edu

Abstract

BACKGROUND: Research during the past 20 years has influenced the management of diagnosis and treatment of children identified as having learning-related vision problems. The intent of this study is to determine whether coherent motion threshold testing can distinguish better-than-average non-disabled (ND) readers from those who are moderately reading disabled (RD) among sixth-grade students. METHOD: A sample of 23 better-than-average non-disabled readers (> or = 80th percentile) and 27 moderately disabled readers (< or = 32nd percentile) were identified using a standardized reading comprehension test. Each participant was tested for coherent motion threshold. Previous psychophysical and fMRI research with adults suggests that coherent motion threshold is a valid measure of magnocellular (M-cell) integrity. RESULTS: The average of two coherent motion threshold trials was significantly greater for moderately reading disabled subjects than for above-average readers ($p < 0.01$). The mean threshold percentage of dots required to observe lateral motion was 9.2% for moderately reading disabled readers and 4.6% for superior readers ($p = 0.001$). CONCLUSION: The outcome of this preliminary study provides an efficient procedure to identify sixth-grade students whose reading disability may be associated with an M-cell deficit. Our previous investigations involving visual processing, visual attention, and oculomotor therapy have resulted in significant improvements in reading comprehension, visual attention, and eye movements. It remains to be demonstrated whether vision therapy has an impact on the M-cell deficit, as measured with coherent motion threshold testing for moderately disabled readers.

12. Is there a common linkage among reading comprehension, visual attention, and magnocellular processing?

Solan HA, Shelley-Tremblay JF, Hansen PC, Larson S.
J Learn Disabil. 2007 May-Jun;40(3):270-8.
Schnurmacher Instititue for Vision Research, State College of Optometry, State University of New York 10036, USA.
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Abstract

The authors examined the relationships between reading comprehension, visual attention, and magnocellular processing in 42 Grade 7 students. The goal was to quantify the sensitivity of visual attention and magnocellular visual processing as concomitants of poor reading comprehension in the absence of either vision therapy or cognitive intervention. Nineteen good readers (M = grade equivalent of 11.2) and 23 poor readers (M = grade equivalent of 3.5) were identified. Participants were tested for visual attention skills (Cognitive Assessment System: CAS) and magnocellular integrity (Coherent Motion Threshold: CM). Individual and combined correlations of dependent variables with reading were significant at the 0.01 level. When combined, the two tests (CAS + CM) accounted for 61% of the variance in reading comprehension. Logistic regression analysis measured sensitivity of the two diagnostic tests. Attention tests correctly classified 95.7% of poor readers, and coherent motion correctly classified 78.3% of poor readers. When the data were combined, 91.3% of poor readers were correctly classified. The research reinforces the notion that a common linkage exists between reading comprehension, visual attention, and magnocellular processing. Diagnostic test batteries for students who have been identified as reading disabled should include magnocellular and visual attention tests. Procedures to diagnose and ameliorate these disabilities are discussed.

13. Making the link between dorsal stream sensitivity and reading.

Kevan A, Pammer K.
Neuroreport. 2008 Mar 5;19(4):467-70.
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Abstract

Different levels of dorsal stream functioning were teased apart to determine whether the observed deficits in dyslexic readers may exist as early as the retinal level, and to explore the relative contribution that the different aspects of dorsal processing may make to reading. The paradigm combining frequency doubled stimuli with endogenous cueing demonstrated that dyslexic readers possess a retinal level magnocellular deficit. Regression analyses provided evidence to suggest that different levels of dorsal processing relates to various aspects of reading skills, with low-level magnocellular M(y) processing relating to reading accuracy and irregular word reading, and dorsal stream functioning relating to all aspects of reading skills, including nonword reading.

14. Magnocellular visual function and children's single word reading.

Cornelissen PL, Hansen PC, Hutton JL, Evangelinou V, Stein JF.
Vision Res. 1998 Feb;38(3):471-82.
Psychology Department, Newcastle University, UK. p.l.cornelissen@ncl.ac.uk

Abstract

Recent research has shown that reading disabled children find it unusually difficult to detect flickering or moving visual stimuli, consistent with impaired processing in the magnocellular visual stream. Yet, it remains controversial to suggest that reduced visual sensitivity of this kind might affect children's reading. Here we suggest that when children read, impaired magnocellular function may degrade information about where letters are positioned with respect to each other, leading to reading errors which contain sounds not represented in the printed word. We call these orthographically inconsistent

nonsense errors "letter" errors. To test this idea we assessed magnocellular function in a sample of 58 unselected children by using a coherent motion detection task. We then gave these children a single word reading task and found that their "letter" errors were best explained by independent contributions from motion detection (i.e., magnocellular function) and phonological awareness (assessed by a spoonerism task). This result held even when chronological age, reading ability, and IQ were controlled for. These findings suggest that impaired magnocellular visual function, as well as phonological deficits may affect how children read.

15. On the relationship between dynamic visual and auditory processing and literacy skills; results from a large primary-school study.

Talcott JB, Witton C, Hebb GS, Stoodley CJ, Westwood EA, France SJ, Hansen PC, Stein JF.
Dyslexia. 2002 Oct-Dec;8(4):204-25
Neurosciences Research Institute, Aston University, Birmingham, UK. j.b.talcott@aston.ac.uk

Abstract

Three hundred and fifty randomly selected primary school children completed a psychometric and psychophysical test battery to ascertain relationships between reading ability and sensitivity to dynamic visual and auditory stimuli. The first analysis examined whether sensitivity to visual coherent motion and auditory frequency resolution differed between groups of children with different literacy and cognitive skills. For both tasks, a main effect of literacy group was found in the absence of a main effect for intelligence or an interaction between these factors. To assess the potential confounding effects of attention, a second analysis of the frequency discrimination data was conducted with performance on catch trials entered as a covariate. Significant effects for both the covariate and literacy skill was found, but again there was no main effect of intelligence, nor was there an interaction between intelligence and literacy skill. Regression analyses were conducted to determine the magnitude of the relationship between sensory and literacy skills in the entire sample. Both visual motion sensitivity and auditory sensitivity to frequency differences were robust predictors of children's literacy skills and their orthographic and phonological skills.

16. All developmental dyslexic subtypes display an elevated motion coherence threshold.

Ridder WH 3rd, Borsting E, Banton T.
Optom Vis Sci. 2001 Jul;78(7):510-7.
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Abstract

PURPOSE: Psychophysical studies indicate that many dyslexics have a motion-processing deficit. The purpose of this study was to determine whether elevated motion coherence thresholds correlate with the specific dyslexic subtypes as defined by the Boder classification scheme. METHODS: Twenty-one dyslexics (seven dyseidetics, six dysphonetics, and eight dysphoneidetics) and 19 age- and gender-matched controls participated in the study. The dyslexics were identified by an exclusionary approach and then subtyped with the Adult Dyslexia Test or the Dyslexia Determination Test. Motion coherence thresholds were determined with random dot kinematograms composed of signal dots and noise dots. Signal dots moved either left or right on each trial, whereas noise dots moved in random directions. The percentage of dots that comprised the signal was varied randomly on each trial (0 to 21% in 3% increments). Subjects guessed the direction of signal dot motion on each trial (two-alternative forced-choice task). A 75% correct threshold was determined with a Weibull equation fit to the psychometric function. RESULTS: All three dyslexic subtypes had elevated motion coherence thresholds (t-test; dyseidetics $p = 0.01$, dysphonetics $p = 0.039$, dysphoneidetics $p = 0.048$). CONCLUSION: Motion-

coherence deficits are not correlated with a specific dyslexic subtype, but, rather, are common to all subtypes. However, some individuals in each of the dyslexic subtypes were found to have normal motion coherence thresholds, suggesting that other factors must be considered to predict the motion sensitivity deficits found in dyslexia.

Other Citations:

1: Solan HA, Shelley-Tremblay JF, Hansen PC, Larson S. Is there a common linkage among reading comprehension, visual attention, and magnocellular processing? J Learn Disabil. 2007 May-Jun;40(3):270-8. PubMed PMID: 17518218.

2: Solan HA, Hansen PC, Shelley-Tremblay J, Ficarra A. Coherent motion threshold measurements for M-cell deficit differ for above- and below-average readers. Optometry. 2003 Nov;74(11):727-34. PubMed PMID: 14653660.

3: Solan HA, Shelley-Tremblay J, Hansen PC, Silverman ME, Larson S, Ficarra A. M-cell deficit and reading disability: a preliminary study of the effects of temporal vision-processing therapy. Optometry. 2004 Oct;75(10):640-50. PubMed PMID: 15508865.

4: Stein J. The magnocellular theory of developmental dyslexia. Dyslexia. 2001 Jan-Mar;7(1):12-36. Review. PubMed PMID: 11305228.

5: Samar VJ, Parasnis I. Cortical locus of coherent motion deficits in deaf poor readers. Brain Cogn. 2007 Apr;63(3):226-39. Epub 2006 Oct 13. PubMed PMID: 17046130.

6: Hutzler F, Kronbichler M, Jacobs AM, Wimmer H. Perhaps correlational but not causal: no effect of dyslexic readers' magnocellular system on their eye movements during reading. Neuropsychologia. 2006;44(4):637-48. Epub 2005 Aug 22. PubMed PMID: 16115655.

7: Samar VJ, Parasnis I. Dorsal stream deficits suggest hidden dyslexia among deaf poor readers: correlated evidence from reduced perceptual speed and elevated coherent motion detection thresholds. Brain Cogn. 2005 Aug;58(3):300-11. PubMed PMID: 15963380.

8: Samar VJ, Parasnis I, Berent GP. Deaf poor readers' pattern reversal visual evoked potentials suggest magnocellular system deficits: implications for diagnostic neuroimaging of dyslexia in deaf individuals. Brain Lang. 2002 Jan;80(1):21-44. PubMed PMID: 11817888.

9: Steinman SB, Steinman BA, Garzia RP. Vision and attention. II: Is visual attention a mechanism through which a deficient magnocellular pathway might cause reading disability? Optom Vis Sci. 1998 Sep;75(9):674-81. PubMed PMID: 9778701.

10: Conlon EG, Sanders MA, Wright CM. Relationships between global motion and global form processing, practice, cognitive and visual processing in adults with dyslexia or visual discomfort. Neuropsychologia. 2009 Feb;47(3):907-15. Epub 2009 Jan 8. PubMed PMID: 19166866.

11: Solan HA, Brannan JR, Ficarra A, Byne R. Transient and sustained processing: effects of varying luminance and wavelength on reading comprehension. J Am Optom Assoc. 1997 Aug;68(8):503-10. PubMed PMID: 9279050.

12: Solan HA, Larson S, Shelley-Tremblay J, Ficarra A, Silverman M. Role of visual attention in cognitive control of oculomotor readiness in students with reading disabilities. J Learn Disabil. 2001 Mar-Apr;34(2):107-18. PubMed PMID: 15497263.

13: Vidyasagar TR, Pammer K. Impaired visual search in dyslexia relates to the role of the magnocellular pathway in attention. Neuroreport. 1999 Apr 26;10(6):1283-7. PubMed PMID: 10363940.

14: Conlon E, Sanders M, Zapart S. Temporal processing in poor adult readers. Neuropsychologia. 2004;42(2):142-57. PubMed PMID: 14644101.

15: Kim J, Davis C, Burnham D, Luksaneeyanawin S. The effect of script on poor readers' sensitivity to dynamic visual stimuli. Brain Lang. 2004 Dec;91(3):326-35. PubMed PMID: 15533558.

16: Billard C, Fluss J, Ducot B, Bricout L, Richard G, Ecalle J, Magnan A, Warszawski J, Ziegler J. [Deficits in reading acquisition in primary school: cognitive, social and behavioral factors studied in a sample of 1062 children]. Rev Epidemiol Sante Publique. 2009 Jun;57(3):191-203. Epub 2009 Apr 24. French. PubMed PMID: 19398285.

17: Wilmer JB, Richardson AJ, Chen Y, Stein JF. Two visual motion processing deficits in developmental dyslexia associated with different reading skills deficits. J Cogn Neurosci. 2004 May;16(4):528-40. PubMed PMID: 15165346.

18: Barnard N, Crewther SG, Crewther DP. Development of a magnocellular function in good and poor primary school-age readers. Optom Vis Sci. 1998 Jan;75(1):62-8. PubMed PMID: 9460788.

19: Skottun BC, Skoyles JR. Coherent motion, magnocellular sensitivity and the causation of dyslexia. Int J Neurosci. 2008 Jan;118(1):185-90. Review. PubMed PMID: 18041615.

20: Solan HA, Shelley-Tremblay J, Ficarra A, Silverman M, Larson S. Effect of attention therapy on reading comprehension. J Learn Disabil. 2003 Nov-Dec;36(6):556-63. PubMed PMID: 15493437.

21: Stoet G, Markey H, López B. Dyslexia and attentional shifting. Neurosci Lett. 2007 Oct 29;427(1):61-5. Epub 2007 Sep 19. PubMed PMID: 17923324.

22: Cestnick L, Coltheart M. The relationship between language-processing and visual-processing deficits in developmental dyslexia. Cognition. 1999 Jul 30;71(3):231-55. PubMed PMID: 10476605.

23: Stein J. Visual motion sensitivity and reading. Neuropsychologia. 2003;41(13):1785-93. Review. PubMed PMID: 14527541.

24: Revheim N, Butler PD, Schechter I, Jalbrzikowski M, Silipo G, Javitt DC. Reading impairment and visual processing deficits in schizophrenia. Schizophr Res. 2006 Oct;87(1-3):238-45. Epub 2006 Aug 4. PubMed PMID: 16890409.

25: Ray NJ, Fowler S, Stein JF. Yellow filters can improve magnocellular function: motion sensitivity, convergence, accommodation, and reading. Ann N Y Acad Sci. 2005 Apr;1039:283-93. PubMed PMID: 15826982.

26: Aaron PG, Joshi M, Williams KA. Not all reading disabilities are alike. J Learn Disabil. 1999 Mar-Apr;32(2):120-37. PubMed PMID: 15499713.

27: Brannan JR, Solan HA, Ficarra AP, Ong E. Effect of luminance on visual evoked potential amplitudes in normal and disabled readers. Optom Vis Sci. 1998 Apr;75(4):279-83. PubMed PMID: 9586753.

28: Commodari E, Guarnera M. Attention and reading skills. Percept Mot Skills. 2005 Apr;100(2):375-86. PubMed PMID: 15974348.

29: Meyler A, Keller TA, Cherkassky VL, Gabrieli JD, Just MA. Modifying the brain activation of poor readers during sentence comprehension with extended remedial instruction: a longitudinal study of neuroplasticity. Neuropsychologia. 2008 Aug;46(10):2580-92. Epub 2008 Mar 25. PubMed PMID: 18495180; PubMed Central PMCID: PMC2598765.

30: Kevan A, Pammer K. Making the link between dorsal stream sensitivity and reading. Neuroreport. 2008 Mar 5;19(4):467-70. PubMed PMID: 18287948.

31: Cornelissen PL, Hansen PC, Hutton JL, Evangelinou V, Stein JF. Magnocellular visual function and children's single word reading. Vision Res. 1998 Feb;38(3):471-82. PubMed PMID: 9536370.

32: Badian NA. Reading disability defined as a discrepancy between listening and reading comprehension: a longitudinal study of stability, gender differences, and prevalence. J Learn Disabil. 1999 Mar-Apr;32(2):138-48. PubMed PMID: 15499714.

33: Talcott JB, Witton C, Hebb GS, Stoodley CJ, Westwood EA, France SJ, Hansen PC, Stein JF. On the relationship between dynamic visual and auditory processing and literacy skills; results from a large primary-school study. Dyslexia. 2002 Oct-Dec;8(4):204-25. PubMed PMID: 12455851.

34: Weinberg WA, McLean A, Brumback RA. Comparison of reading and listening-reading techniques for administration of PIAT Reading Comprehension subtest: justification for the bypass approach. Percept Mot Skills. 1988 Apr;66(2):672-4. PubMed PMID: 3399347.

35: Fluss J, Ziegler JC, Warszawski J, Ducot B, Richard G, Billard C. Poor reading in French elementary school: the interplay of cognitive, behavioral, and socioeconomic factors. J Dev Behav Pediatr. 2009 Jun;30(3):206-16. PubMed PMID: 19412126.

36: Kak AV, Brown DR. Visual pattern perception: a multidimensional analysis of development of children's reading skills. Percept Mot Skills. 1979 Dec;49(3):819-30. PubMed PMID: 530782.

37: Kinsey K, Rose M, Hansen P, Richardson A, Stein J. Magnocellular mediated visual-spatial attention and reading ability. Neuroreport. 2004 Oct 5;15(14):2215-8. PubMed PMID: 15371736.

38: Heim S, Tschierse J, Amunts K, Wilms M, Vossel S, Willmes K, Grabowska A, Huber W. Cognitive subtypes of dyslexia. Acta Neurobiol Exp (Wars). 2008;68(1):73-82. PubMed PMID: 18389017.

39: Kim D, Wylie G, Pasternak R, Butler PD, Javitt DC. Magnocellular contributions to impaired motion processing in schizophrenia. Schizophr Res. 2006 Feb 15;82(1):1-8. Epub 2005 Dec 1. PubMed PMID: 16325377; PubMed Central PMCID: PMC2045640.

40: Kevan A, Pammer K. Visual deficits in pre-readers at familial risk for dyslexia. Vision Res. 2008 Dec;48(28):2835-9. Epub 2008 Oct 30. PubMed PMID: 18929591.

41: Demb JB, Boynton GM, Heeger DJ. Functional magnetic resonance imaging of early visual pathways in dyslexia. J Neurosci. 1998 Sep 1;18(17):6939-51. PubMed PMID: 9712663.

42: Talcott JB, Gram A, Van Ingelghem M, Witton C, Stein JF, Toennessen FE. Impaired sensitivity to dynamic stimuli in poor readers of a regular orthography. Brain Lang. 2003 Nov;87(2):259-66. PubMed PMID: 14585295.

43: Dain SJ, Floyd RA, Elliot RT. Color and luminance increment thresholds in poor readers. Vis Neurosci. 2008 May-Jun;25(3):481-6. PubMed PMID: 18598422.

44: Meyler A, Breznitz Z. Visual, auditory and cross-modal processing of linguistic and nonlinguistic temporal patterns among adult dyslexic readers. Dyslexia. 2005 May;11(2):93-115. PubMed PMID: 15918369.

45: Macaruso P, Bar-Shalom E, Crain S, Shankweiler D. Comprehension of temporal terms by good and poor readers. Lang Speech. 1989 Jan-Mar;32 (Pt 1):45-67. PubMed PMID: 2622300.

46: Aaron PG. Can reading disabilities be diagnosed without using intelligence tests? J Learn Disabil. 1991 Mar;24(3):178-86, 191. PubMed PMID: 2026959.

47: Skottun BC, Skoyles JR. A few remarks on relating reaction time to magnocellular activity. J Clin Exp Neuropsychol. 2007 Nov;29(8):860-6. Epub 2007 Feb 14. Review. PubMed PMID: 17852604.

48: Swanson HL, Howard CB, Sáez L. Do different components of working memory underlie different subgroups of reading disabilities? J Learn Disabil. 2006 May-Jun;39(3):252-69. PubMed PMID: 16724796.

49: Ram-Tsur R, Faust M, Zivotofsky AZ. Poor performance on serial visual tasks in persons with reading disabilities: impaired working memory? J Learn Disabil. 2008 Sep-Oct;41(5):437-50. PubMed PMID: 18768775.

50: Sperling AJ, Lu ZL, Manis FR, Seidenberg MS. Motion-perception deficits and reading impairment: it's the noise, not the motion. Psychol Sci. 2006 Dec;17(12):1047-53. PubMed PMID: 17201786.

51: Kevan A, Pammer K. Predicting early reading skills from pre-reading measures of dorsal stream functioning. Neuropsychologia. 2009 Dec;47(14):3174-81. Epub 2009 Aug 3. PubMed PMID: 19651148.

52: Solman RT, Dain SJ, Lim HS, May JG. Reading-related wavelength and spatial frequency effects in visual spatial location. Ophthalmic Physiol Opt. 1995 Mar;15(2):125-32. PubMed PMID: 7659408.

53: Everatt J, Bradshaw MF, Hibbard PB. Visual processing and dyslexia. Perception. 1999;28(2):243-54. PubMed PMID: 10615463.

54: Aaron PG, Joshi RM, Phipps J. A cognitive tool to diagnose predominantly inattentive ADHD behavior. J Atten Disord. 2004 Feb;7(3):125-35. PubMed PMID: 15260170.

55: Boden C, Giaschi D. M-stream deficits and reading-related visual processes in developmental dyslexia. Psychol Bull. 2007 Mar;133(2):346-66. Review. PubMed PMID: 17338604.

56: Sperling AJ, Lu ZL, Manis FR, Seidenberg MS. Deficits in achromatic phantom contour perception in poor readers. Neuropsychologia. 2006;44(10):1900-8. Epub 2006 Mar 31. PubMed PMID: 16580029.

57: Amitay S, Ben-Yehudah G, Banai K, Ahissar M. Disabled readers suffer from visual and auditory impairments but not from a specific magnocellular deficit. Brain. 2002 Oct;125(Pt 10):2272-85. PubMed PMID: 12244084.

58: Cornelissen PL, Hansen PC, Gilchrist I, Cormack F, Essex J, Frankish C. Coherent motion detection and letter position encoding. Vision Res. 1998 Jul;38(14):2181-91. PubMed PMID: 9797977.

59: Wilkinson IA, Elkins J, Bain JD. Individual differences in story comprehension and recall of poor readers. Br J Educ Psychol. 1995 Dec;65 (Pt 4):393-407. PubMed PMID: 8580046.

60: Pammer K, Wheatley C. Isolating the M(y)-cell response in dyslexia using the spatial frequency doubling illusion. Vision Res. 2001 Jul;41(16):2139-47. PubMed PMID: 11403797.

61: Meyler A, Keller TA, Cherkassky VL, Lee D, Hoeft F, Whitfield-Gabrieli S, Gabrieli JD, Just MA. Brain activation during sentence comprehension among good and poor readers. Cereb Cortex. 2007 Dec;17(12):2780-7. Epub 2007 Feb 21. PubMed PMID: 17317678; PubMed Central PMCID: PMC2599909.

62: Floyd RA, Dain SJ, Elliott RT. Is the perception of brightness different in poor readers? Vision Res. 2004 Jan;44(2):221-7. PubMed PMID: 14637370.

63: Williams MC, Lecluyse K. Perceptual consequences of a temporal processing deficit in reading disabled children. J Am Optom Assoc. 1990 Feb;61(2):111-21. PubMed PMID: 2313028.

64: Griffin JR, Birch TF, Bateman GF, De Land PN. Dyslexia and visual perception: is there a relation? Optom Vis Sci. 1993 May;70(5):374-9. PubMed PMID: 8515965.

65: Kruk R, Sumbler K, Willows D. Visual processing characteristics of children with Meares-Irlen syndrome. Ophthalmic Physiol Opt. 2008 Jan;28(1):35-46. PubMed PMID: 18201334.

66: Jones MW, Branigan HP, Kelly ML. Visual deficits in developmental dyslexia: relationships between non-linguistic visual tasks and their contribution to components of reading. Dyslexia. 2008 May;14(2):95-115. PubMed PMID: 17874457.

67: Skottun BC, Skoyles JR. Attention, reading and dyslexia. Clin Exp Optom. 2006 Jul;89(4):241-5. Review. PubMed PMID: 16776731.

68: Lorusso ML, Facoetti A, Pesenti S, Cattaneo C, Molteni M, Geiger G. Wider recognition in peripheral vision common to different subtypes of dyslexia. Vision Res. 2004;44(20):2413-24. PubMed PMID: 15246756.

69: Matthews AJ, Martin FH. Electrophysiological indices of spatial attention during global/local processing in good and poor phonological decoders. Brain Lang. 2009 Dec;111(3):152-60. Epub 2009 Oct 13. PubMed PMID: 19828188.

70: Skottun BC, Skoyles JR. Is coherent motion an appropriate test for magnocellular sensitivity? Brain Cogn. 2006 Jul;61(2):172-80. Epub 2006 Feb 7. Review. PubMed PMID: 16455172.

71: Le Fevre DM, Moore DW, Wilkinson IA. Tape-assisted reciprocal teaching: cognitive bootstrapping for poor decoders. Br J Educ Psychol. 2003 Mar;73(Pt 1):37-58. PubMed PMID: 12639276.

72: Dirks E, Spyer G, van Lieshout EC, de Sonneville L. Prevalence of combined reading and arithmetic disabilities. J Learn Disabil. 2008 Sep-Oct;41(5):460-73. PubMed PMID: 18768777.

73: Tiu RD Jr, Thompson LA, Lewis BA. The role of IQ in a component model of reading. J Learn Disabil. 2003 Sep-Oct;36(5):424-36. PubMed PMID: 15497486.

74: Semrud-Clikeman M, Glass K. Comprehension of humor in children with nonverbal learning disabilities, reading disabilities, and without learning disabilities. Ann Dyslexia. 2008 Dec;58(2):163-80. Epub 2008 Aug 26. PubMed PMID: 18726696.

75: Segalowitz SJ, Wagner WJ, Menna R. Lateral versus frontal ERP predictors of reading skill. Brain Cogn. 1992 Sep;20(1):85-103. PubMed PMID: 1389125.

76: Steinbrink C, Klatte M. Phonological working memory in German children with poor reading and spelling abilities. Dyslexia. 2008 Nov;14(4):271-90. PubMed PMID: 17979186.

77: Torppa M, Tolvanen A, Poikkeus AM, Eklund K, Lerkkanen MK, Leskinen E, Lyytinen H. Reading development subtypes and their early characteristics. Ann Dyslexia. 2007 Jun;57(1):3-32. Epub 2007 May 30. PubMed PMID: 17849214.

78: Tunmer WE, Chapman JW. U language-related differences between discrepancy-defined and non-discrepancy-defined poor readers: a longitudinal study of dyslexia in New Zealand. Dyslexia. 2007 Feb;13(1):42-66. PubMed PMID: 17330735.

79: Schulz E, Maurer U, van der Mark S, Bucher K, Brem S, Martin E, Brandeis D. Reading for meaning in dyslexic and young children: distinct neural pathways but common endpoints. Neuropsychologia. 2009 Oct;47(12):2544-57. Epub 2009 May 9. PubMed PMID: 19433099.

80: Spring C, French L. Identifying children with specific reading disabilities from listening and reading discrepancy scores. J Learn Disabil. 1990 Jan;23(1):53-8. PubMed PMID: 2295871.

81: Bowey JA. Is a "Phoenician" reading style superior to a "Chinese" reading style? Evidence from fourth graders. J Exp Child Psychol. 2008 Jul;100(3):186-214. Epub 2007 Dec 3. PubMed PMID: 18054365.

82: Vidyasagar TR. Attentional gating in primary visual cortex: a physiological basis for dyslexia. Perception. 2005;34(8):903-11. Review. PubMed PMID: 16178142.

83: Martin F, Lovegrove W. The effects of field size and luminance on contrast sensitivity differences between specifically reading disabled and normal children. Neuropsychologia. 1984;22(1):73-7. PubMed PMID: 6709178.

84: Levin JR. Inducing comprehension in poor readers: a test of a recent model. J Educ Psychol. 1973 Aug;65(1):19-24. PubMed PMID: 4726313.

85: Knivsberg AM, Andreassen AB. Behaviour, attention and cognition in severe dyslexia. Nord J Psychiatry. 2008;62(1):59-65. PubMed PMID: 18389427.

86: Catts HW, Hogan TP, Fey ME. Subgrouping poor readers on the basis of individual differences in reading-related abilities. J Learn Disabil. 2003 Mar-Apr;36(2):151-64. PubMed PMID: 15493430; PubMed Central PMCID: PMC2848965.

87: Farrag AF, Khedr EM, Abel-Naser W. Impaired parvocellular pathway in dyslexic children. Eur J Neurol. 2002 Jul;9(4):359-63. PubMed PMID: 12099918.

88: Miller JW, McKenna MC. Disabled readers: their intellectual and perceptual capacities at differing ages. Percept Mot Skills. 1981 Apr;52(2):467-72. PubMed PMID: 7255059.

89: Gillund B, Ferraro FR. Allocation of attention during word recognition by good and poor readers. Percept Mot Skills. 1996 Jun;82(3 Pt 1):899-902. PubMed PMID: 8774029.

90: Skoyles J, Skottun BC. On the prevalence of magnocellular deficits in the visual system of non-dyslexic individuals. Brain Lang. 2004 Jan;88(1):79-82. Review. PubMed PMID: 14698733.

91: Graves RE, Frerichs RJ, Cook JA. Visual localization in dyslexia. Neuropsychology. 1999 Oct;13(4):575-81. PubMed PMID: 10527066.

92: Stuart GW, McAnally KI, Castles A. Can contrast sensitivity functions in dyslexia be explained by inattention rather than a magnocellular deficit? Vision Res. 2001 Nov;41(24):3205-11. Review. PubMed PMID: 11711144.

93: Jiménez JE, Rodríguez C, Ramírez G. Spanish developmental dyslexia: prevalence, cognitive profile, and home literacy experiences. J Exp Child Psychol. 2009 Jun;103(2):167-85. Epub 2009 Mar 24. PubMed PMID: 19321176.

94: Shaywitz SE, Shaywitz BA. Paying attention to reading: the neurobiology of reading and dyslexia. Dev Psychopathol. 2008 Fall;20(4):1329-49. Review. PubMed PMID: 18838044.

95: Garzia RP, Nicholson SB. Visual function and reading disability: an optometric viewpoint. J Am Optom Assoc. 1990 Feb;61(2):88-97. Review. PubMed PMID: 2179385.

96: DiCerbo KE, Oliver J, Albers C, Blanchard J. Effects of reducing attentional demands on performance of reading comprehension tests by third graders. Percept Mot Skills. 2004 Apr;98(2):561-74. PubMed PMID: 15141921.

97: King B, Wood C, Faulkner D. Sensitivity to visual and auditory stimuli in children with developmental dyslexia. Dyslexia. 2008 May;14(2):116-41. PubMed PMID: 17937386.

98: Sesma HW, Mahone EM, Levine T, Eason SH, Cutting LE. The contribution of executive skills to reading comprehension. Child Neuropsychol. 2009 May;15(3):232-46. PubMed PMID: 18629674; PubMed Central PMCID: PMC2728040.

99: Bowyer-Crane C, Snowling MJ. Assessing children's inference generation: what do tests of reading comprehension measure? Br J Educ Psychol. 2005 Jun;75(Pt 2):189-201. PubMed PMID: 16033662.

100: Solan HA, Ficarra AP. A study of perceptual and verbal skills of disabled readers in grades 4, 5 and 6. J Am Optom Assoc. 1990 Aug;61(8):628-34. PubMed PMID: 2394903.

101: Walker MM. Visual and lexical factors in naming speed by children with reading disorders. Percept Mot Skills. 2002 Dec;95(3 Pt 2):1196-8. PubMed PMID: 12578260.

102: Nelson RL, Damico JS, Smith SK. Applying eye movement miscue analysis to the reading patterns of children with language impairment. Clin Linguist Phon. 2008 Apr-May;22(4-5):293-303. PubMed PMID: 18415728.

103: Stein J, Walsh V. To see but not to read; the magnocellular theory of dyslexia. Trends Neurosci. 1997 Apr;20(4):147-52. PubMed PMID: 9106353.

104: Register D, Darrow AA, Standley J, Swedberg O. The use of music to enhance reading skills of second grade students and students with reading disabilities. J Music Ther. 2007 Spring;44(1):23-37. PubMed PMID: 17419662.

105: Terepocki M, Kruk RS, Willows DM. The incidence and nature of letter orientation errors in reading disability. J Learn Disabil. 2002 May-Jun;35(3):214-33. PubMed PMID: 15493319.

106: Schulte-Körne G, Bartling J, Deimel W, Remschmidt H. Spatial-frequency- and contrast-dependent visible persistence and reading disorder: no evidence for a basic perceptual deficit. J Neural Transm. 2004 Jul;111(7):941-50. Epub 2004 Apr 8. PubMed PMID: 15206008.

107: Sharma M, Purdy SC, Kelly AS. Comorbidity of auditory processing, language, and reading disorders. J Speech Lang Hear Res. 2009 Jun;52(3):706-22. Epub 2008 Dec 8. PubMed PMID: 19064904.

108: Solan HA, Ficarra A, Brannan JR, Rucker F. Eye movement efficiency in normal and reading disabled elementary school children: effects of varying luminance and wavelength. J Am Optom Assoc. 1998 Jul;69(7):455-64. PubMed PMID: 9697381.

109: Barnes J, Hinkley L, Masters S, Boubert L. Visual memory transformations in dyslexia. Percept Mot Skills. 2007 Jun;104(3 Pt 1):881-91. PubMed PMID: 17688144.

110: Georgiou GK, Das JP, Hayward D. Revisiting the "simple view of reading" in a group of children with poor reading comprehension. J Learn Disabil. 2009 Jan-Feb;42(1):76-84. Epub 2008 Nov 5. PubMed PMID: 18987265.

111: Wise JC, Sevcik RA, Morris RD, Lovett MW, Wolf M. The relationship among receptive and expressive vocabulary, listening comprehension, pre-reading skills, word identification skills, and reading comprehension by children with reading disabilities. J Speech Lang Hear Res. 2007 Aug;50(4):1093-109. PubMed PMID: 17675607.

112: Mitchell C, Mansfield D, Rautenbach S. Coloured filters and reading accuracy, comprehension and rate: a placebo-controlled study. Percept Mot Skills. 2008 Apr;106(2):517-32. PubMed PMID: 18556906.

113: Dye MW, Hauser PC, Bavelier D. Visual skills and cross-modal plasticity in deaf readers: possible implications for acquiring meaning from print. Ann N Y Acad Sci. 2008 Dec;1145:71-82. Review. PubMed PMID: 19076390.

114: Kidd JC, Hogben JH. Does the auditory saltation stimulus distinguish dyslexic from competently reading adults? J Speech Lang Hear Res. 2007 Aug;50(4):982-98. PubMed PMID: 17675600.

115: Kuba M, Szanyi J, Gayer D, Kremlácek J, Kubová Z. Electrophysiological testing of dyslexia. Acta Medica (Hradec Kralove). 2001;44(4):131-4. PubMed PMID: 11836848.

116: Carroll TA, Mullaney P, Eustace P. Dark adaptation in disabled readers screened for Scotopic Sensitivity Syndrome. Percept Mot Skills. 1994 Feb;78(1):131-41. PubMed PMID: 8177650.

117: Krasowicz-Kupis G, Borkowska AR, Pietras I. Rapid automatized naming, phonology and dyslexia in Polish children. Med Sci Monit. 2009 Sep;15(9):CR460-9. PubMed PMID: 19721397.

118: Germano GD, Capellini SA. Efficacy of an audio-visual computerized remediation program in students with dyslexia. Pro Fono. 2008 Oct-Dec;20(4):237-42. PubMed PMID: 19142466.

119: Spencer P, Delk L. Hearing-impaired students' performance on tests of visual processing: relationships with reading performance. Am Ann Deaf. 1989 Dec;134(5):333-7. PubMed PMID: 2618923.

120: Crewther SG, Crewther DP, Klistorner A, Kiely PM. Development of the magnocellular VEP in children: implications for reading disability. Electroencephalogr Clin Neurophysiol Suppl. 1999;49:123-8. PubMed PMID: 10533097.

121: Skottun BC. Magnocellular reading and dyslexia. Vision Res. 2005 Jan;45(1):133-4; author reply 135-6. PubMed PMID: 15571743.

122: Goldstand S, Koslowe KC, Parush S. Vision, visual-information processing, and academic performance among seventh-grade schoolchildren: a more significant relationship than we thought? Am J Occup Ther. 2005 Jul-Aug;59(4):377-89. PubMed PMID: 16124204.

123: Hogben JH, Pratt C, Dedman K, Clark CD. Blurring the image does not help disabled readers. Vision Res. 1996 May;36(10):1503-7. PubMed PMID: 8762767.

124: Rayner K, Castelhano MS, Yang J. Eye movements and the perceptual span in older and younger readers. Psychol Aging. 2009 Sep;24(3):755-60. PubMed PMID: 19739933.

125: Demb JB, Boynton GM, Heeger DJ. Brain activity in visual cortex predicts individual differences in reading performance. Proc Natl Acad Sci U S A. 1997 Nov 25;94(24):13363-6. PubMed PMID: 9371851; PubMed Central PMCID: PMC24314.

126: Michael M. Responses on a lateralized lexical decision task relate to both reading times and comprehension. Brain Cogn. 2009 Dec;71(3):416-26. Epub 2009 Jun 25. PubMed PMID: 19559514.

127: Stoodley CJ, Ray NJ, Jack A, Stein JF. Implicit learning in control, dyslexic, and garden-variety poor readers. Ann N Y Acad Sci. 2008 Dec;1145:173-83. PubMed PMID: 19076396.

128: Murphy CF, Schochat E. Correlations between reading, phonological awareness and auditory temporal processing. Pro Fono. 2009 Jan-Mar;21(1):13-8. PubMed PMID: 19360253.

129: Prado C, Dubois M, Valdois S. The eye movements of dyslexic children during reading and visual search: impact of the visual attention span. Vision Res. 2007 Sep;47(19):2521-30. Epub 2007 Aug 23. PubMed PMID: 17719073.

130: Miller P, Kupfermann A. The role of visual and phonological representations in the processing of written words by readers with diagnosed dyslexia: evidence from a working memory task. Ann Dyslexia. 2009 Jun;59(1):12-33. Epub 2009 Mar 24. PubMed PMID: 19308736.

131: Skottun BC, Skoyles JR. Attention, dyslexia, and the line-motion illusion. Optom Vis Sci. 2006 Nov;83(11):843-9. Review. PubMed PMID: 17106412.

132: Au A, Lovegrove W. Rapid visual processing by college students in reading irregular words and phonologically regular pseudowords presented singly and in contiguity. Ann Dyslexia. 2006 Dec;56(2):335-60. PubMed PMID: 17849204.

133: Shaywitz SE, Morris R, Shaywitz BA. The education of dyslexic children from childhood to young adulthood. Annu Rev Psychol. 2008;59:451-75. Review. PubMed PMID: 18154503.

134: English KP. Visual perception and reading disabilities. Aust J Ophthalmol. 1981 Aug;9(3):181-4. PubMed PMID: 6765665.

135: Maxwell AE, Fenwick PB, Fenton GW, Dollimore J. Reading ability and brain function: a simple statistical model. Psychol Med. 1974 Aug;4(3):274-80. PubMed PMID: 4427975.

136: Wright CM, Conlon EG. Auditory and visual processing in children with dyslexia. Dev Neuropsychol. 2009;34(3):330-55. PubMed PMID: 19437207.
137: Vidyasagar TR. Neural underpinnings of dyslexia as a disorder of visuo-spatial attention. Clin Exp Optom. 2004 Jan;87(1):4-10. Review. PubMed PMID: 14720113.

138: Solman RT, Dain SJ, Keech SL. Color-mediated contrast sensitivity in disabled readers. Optom Vis Sci. 1991 May;68(5):331-7. PubMed PMID: 1852393.

139: Leong CK, Hau KT, Tse SK, Loh KY. Component skills of text comprehension in less competent Chinese comprehenders. Ann Dyslexia. 2007 Jun;57(1):75-97. Epub 2007 May 26. PubMed PMID: 17849217.

140: Sannomiya M. Modality effect on text processing as a function of ability to comprehend. Percept Mot Skills. 1984 Apr;58(2):379-82. PubMed PMID: 6739234.

141: Chase C, Dougherty RF, Ray N, Fowler S, Stein J. L/M speed-matching ratio predicts reading in children. Optom Vis Sci. 2007 Mar;84(3):229-36. PubMed PMID: 17435537.

142: Williams MC, May JG, Solman R, Zhou H. The effects of spatial filtering and contrast reduction on visual search times in good and poor readers. Vision Res. 1995 Jan;35(2):285-91. PubMed PMID: 7839623.

143: Blau V, van Atteveldt N, Ekkebus M, Goebel R, Blomert L. Reduced neural integration of letters and speech sounds links phonological and reading deficits in adult dyslexia. Curr Biol. 2009 Mar 24;19(6):503-8. Epub 2009 Mar 12. Erratum in: Curr Biol. 2009 Jun 23;19(12):1064. PubMed PMID: 19285401.

144: Atkinson J, Braddick O. Visual and visuocognitive development in children born very prematurely. Prog Brain Res. 2007;164:123-49. Review. PubMed PMID: 17920429.

145: Thaler V, Urton K, Heine A, Hawelka S, Engl V, Jacobs AM. Different behavioral and eye movement patterns of dyslexic readers with and without attentional deficits during single word reading. Neuropsychologia. 2009 Oct;47(12):2436-45. Epub 2009 Apr 19. PubMed PMID: 19383502.

146: Christenson GN, Griffin JR, Taylor M. Failure of blue-tinted lenses to change reading scores of dyslexic individuals. Optometry. 2001 Oct;72(10):627-33. PubMed PMID: 11712629.
147: Ganschow L, Weber DB. Effects of mode of presentation on comprehension of below average, average and above average readers. Percept Mot Skills. 1987 Jun;64(3 Pt 1):899-905. PubMed PMID: 3601609.

148: Cutting LE, Materek A, Cole CA, Levine TM, Mahone EM. Effects of fluency, oral language, and executive function on reading comprehension performance. Ann Dyslexia. 2009 Jun;59(1):34-54. Epub 2009 Apr 25. PubMed PMID: 19396550; PubMed Central PMCID: PMC2757040.

149: Regtvoort AG, van Leeuwen TH, Stoel RD, van der Leij A. Efficiency of visual information processing in children at-risk for dyslexia: habituation of single-trial ERPs. Brain Lang. 2006 Sep;98(3):319-31. Epub 2006 Jul 25. PubMed PMID: 16870246.

150: Samuelstuen MS, Bråten I. Decoding, knowledge, and strategies in comprehension of expository text. Scand J Psychol. 2005 Apr;46(2):107-17. PubMed PMID: 15762939.

151: Skottun BC, Skoyles JR. Dyslexia and rapid visual processing: a commentary. J Clin Exp Neuropsychol. 2008 Aug;30(6):666-73. PubMed PMID: 18612875.

152: Yamada J. Neurological origins of poor reading comprehension despite fast word decoding? Brain Lang. 2002 Feb;80(2):253-9. PubMed PMID: 11827447.

153: Törmänen MR, Takala M. Auditory processing in developmental dyslexia: an exploratory study of an auditory and visual matching training program with Swedish children with developmental dyslexia. Scand J Psychol. 2009 Jun;50(3):277-85. Epub 2009 Mar 2. PubMed PMID: 19302414.

154: Grizzle KL. Developmental dyslexia. Pediatr Clin North Am. 2007 Jun;54(3):507-23, vi. Review. PubMed PMID: 17543907.

155: Laycock R, Crewther SG. Towards an understanding of the role of the 'magnocellular advantage' in fluent reading. Neurosci Biobehav Rev. 2008 Oct;32(8):1494-506. Epub 2008 Jun 7. Review. PubMed PMID: 18588912.

156: Valdois S, Habib M, Cohen L. [The reader brain: natural and cultural story]. Rev Neurol (Paris). 2008 May;164 Suppl 3:S77-82. Review. French. PubMed PMID: 18675051.
157: Stenneken P, van Eimeren L, Keller I, Jacobs AM, Kerkhoff G. Task-dependent modulation of neglect dyslexia? Novel evidence from the viewing position effect. Brain Res. 2008 Jan 16;1189:166-78. Epub 2007 Nov 12. PubMed PMID: 18054900.

158: Legein CP, Bouma H. Reading and the ophthalmologist. An introduction into the complex phenomenon of ordinary reading as a guideline for analysis and treatment of disabled readers. Doc Ophthalmol. 1982 Sep 30;53(2):123-57. PubMed PMID: 7173014.

159: Vidal-López J, Romera-Vivancos JA. Is manipulation of color effective in study of the global precedence effect? Percept Mot Skills. 2009 Apr;108(2):631-5. PubMed PMID: 19544968.

160: Friedmann N, Lukov L. Developmental surface dyslexias. Cortex. 2008 Oct;44(9):1146-60. Epub 2008 Mar 4. PubMed PMID: 18761129.

161: van Bon WH, Bouwmans M, Broeders IN. The prevalence of poor reading in Dutch special elementary education. J Learn Disabil. 2006 Nov-Dec;39(6):482-95. PubMed PMID: 17165616.

162: Billard C, Fluss J, Ducot B, Warszawski J, Ecalle J, Magnan A, Richard G, Ziegler J. [Study of causal factors of reading impairment in a sample of 1062 7 to 8-year-old children]. Arch Pediatr. 2008 Jun;15(6):1058-67. Epub 2008 May 5. French. PubMed PMID: 18456475.

163: Lovegrove WJ, Garzia RP, Nicholson SB. Experimental evidence for a transient system deficit in specific reading disability. J Am Optom Assoc. 1990 Feb;61(2):137-46. Review. PubMed PMID: 2179383.

164: Fiset S, Arguin M, Fiset D. An attempt to simulate letter-by-letter dyslexia in normal readers. Brain Lang. 2006 Sep;98(3):251-63. Epub 2006 Jun 16. PubMed PMID: 16781767.

165: Oexle JE, Zenhausern R. Differential hemispheric activation in good and poor readers. Int J Neurosci. 1981;15(1-2):31-6. PubMed PMID: 7287326.

166: Skottun BC, Skoyles J. Dyslexia, direction selectivity and magnocellular sensitivity. Vision Res. 2007 Jun;47(14):1974-5; author reply 1976-7. Epub 2007 Feb 20. PubMed PMID: 17316741.

167: Abrams DA, Nicol T, Zecker S, Kraus N. Abnormal cortical processing of the syllable rate of speech in poor readers. J Neurosci. 2009 Jun 17;29(24):7686-93. PubMed PMID: 19535580; PubMed Central PMCID: PMC2763585.

168: van den Bos KP, Nakken H, Nicolay PG, van Houten EJ. Adults with mild intellectual disabilities: can their reading comprehension ability be improved? J Intellect Disabil Res. 2007 Nov;51(Pt 11):835-49. PubMed PMID: 17910536.

169: Boets B, Wouters J, van Wieringen A, De Smedt B, Ghesquière P. Modelling relations between sensory processing, speech perception, orthographic and phonological ability, and literacy achievement. Brain Lang. 2008 Jul;106(1):29-40. Epub 2008 Jan 18. PubMed PMID: 18207564.

170: Rastatter MP, Barrow IM, Stuart A. The effects of frequency altered feedback on reading comprehension abilities of normal and reading disordered children. Neurosci Lett. 2007 Apr 18;416(3):266-71. Epub 2007 Feb 7. PubMed PMID: 17335971.

171: Bralet MC, Navarre M, Eskenazi AM, Lucas-Ross M, Falissard B. [Interest of a new instrument to assess cognition in schizophrenia: The Brief Assessment of Cognition in Schizophrenia (BACS)]. Encephale. 2008 Dec;34(6):557-62. Epub 2008 Jul 9. French. PubMed PMID: 19081451.

172: Skottun BC, Skoyles JR. A few remarks on attention and magnocellular deficits in schizophrenia. Neurosci Biobehav Rev. 2008;32(1):118-22. Epub 2007 Jun 27. Review. PubMed PMID: 17651801.

173: Schuett S, Heywood CA, Kentridge RW, Zihl J. The significance of visual information processing in reading: Insights from hemianopic dyslexia. Neuropsychologia. 2008 Aug;46(10):2445-62. Epub 2008 May 2. Review. PubMed PMID: 18533203.

174: Stine-Morrow EA, Gagne DD, Morrow DG, DeWall BH. Age differences in rereading. Mem Cognit. 2004 Jul;32(5):696-710. PubMed PMID: 15552347.

175: Butter EJ, Vallano TW. Auditory and visual cognitive styles and adult reading performance. Percept Mot Skills. 1978 Dec;47(3 Pt 1):995-8. PubMed PMID: 740503.

176: Carmean SL, Regeth RA. Optimum level of visual contrast sensitivity for reading comprehension. Percept Mot Skills. 1990 Dec;71(3 Pt 1):755-62. PubMed PMID: 2293177.

177: Laycock R, Crewther SG, Crewther DP. A role for the 'magnocellular advantage' in visual impairments in neurodevelopmental and psychiatric disorders. Neurosci Biobehav Rev. 2007;31(3):363-76. Epub 2006 Dec 1. Review. PubMed PMID: 17141311.

178: Rvachew S. Phonological processing and reading in children with speech sound disorders. Am J Speech Lang Pathol. 2007 Aug;16(3):260-70. PubMed PMID: 17666551.

179: Patching GR, Jordan TR. Spatial frequency sensitivity differences between adults of good and poor reading ability. Invest Ophthalmol Vis Sci. 2005 Jun;46(6):2219-24. PubMed PMID: 15914644.

180: Varney NR. How reading works: considerations from prehistory to the present. Appl Neuropsychol. 2002;9(1):3-12. PubMed PMID: 12173748.

181: Solman RT, Cho HS, Dain SJ. Colour-mediated grouping effects in good and disabled readers. Ophthalmic Physiol Opt. 1991 Oct;11(4):320-7. PubMed PMID: 1771068.

182: Bednarek DB, Tarnowski A, Grabowska A. Latencies of stimulus-driven eye movements are shorter in dyslexic subjects. Brain Cogn. 2006 Feb;60(1):64-9. Epub 2005 Dec 20. PubMed PMID: 16364529.

183: Brannan JR, Williams MC. Allocation of visual attention in good and poor readers. Percept Psychophys. 1987 Jan;41(1):23-8. PubMed PMID: 3822740.

184: Singleton C, Henderson LM. Computerized screening for visual stress in children with dyslexia. Dyslexia. 2007 May;13(2):130-51. PubMed PMID: 17557688.

185: Skottun BC. On the use of metacontrast to assess magnocellular function in dyslexic readers. Percept Psychophys. 2001 Oct;63(7):1271-4. Review. PubMed PMID: 11766950.

186: Ridder WH 3rd, Borsting E, Tosha C, Tong A, Dougherty R, Chase C. ERGs and psychophysical thresholds in students with reading discomfort. Optom Vis Sci. 2008 Mar;85(3):180-6. PubMed PMID: 18317333.

187: Dubey DR, O'leary SG. Increasing reading comprehension of two hyperactive children: preliminary investigation. Percept Mot Skills. 1975 Dec;41(3):691-4. PubMed PMID: 1215108.

188: Judge J, Caravolas M, Knox PC. Visual attention in adults with developmental dyslexia: evidence from manual reaction time and saccade latency. Cogn Neuropsychol. 2007 May;24(3):260-78. PubMed PMID: 18416491.

189: Au A, Lovegrove B. Temporal processing ability in above average and average readers. Percept Psychophys. 2001 Jan;63(1):148-55. PubMed PMID: 11304010.

190: Bolger DJ, Minas J, Burman DD, Booth JR. Differential effects of orthographic and phonological consistency in cortex for children with and without reading impairment. Neuropsychologia. 2008 Dec;46(14):3210-24. PubMed PMID: 18725239; PubMed Central PMCID: PMC2658621.

191: Bennett IJ, Romano JC, Howard JH Jr, Howard DV. Two forms of implicit learning in young adults with dyslexia. Ann N Y Acad Sci. 2008 Dec;1145:184-98. PubMed PMID: 19076397; PubMed Central PMCID: PMC2691650.

192: Christenson GN, Griffin JR, Wesson MD. Optometry's role in reading disabilities: resolving the controversy. J Am Optom Assoc. 1990 May;61(5):363-72. Review. PubMed PMID: 2191996.

193: Koponen T, Aunola K, Ahonen T, Nurmi JE. Cognitive predictors of single-digit and procedural calculation skills and their covariation with reading skill. J Exp Child Psychol. 2007 Jul;97(3):220-41. PubMed PMID: 17560969.

194: Gabrieli JD. Dyslexia: a new synergy between education and cognitive neuroscience. Science. 2009 Jul 17;325(5938):280-3. Review. PubMed PMID: 19608907.

195: Pitchford NJ, Ledgeway T, Masterson J. Reduced orthographic learning in dyslexic adult readers: evidence from patterns of letter search. Q J Exp Psychol (Colchester). 2009 Jan;62(1):99-113. Epub 2008 Feb 20. PubMed PMID: 18609393.

196: Laing SP, Kamhi AG. The use of think-aloud protocols to compare inferencing abilities in average and below-average readers. J Learn Disabil. 2002 Sep-Oct;35(5):436-47. PubMed PMID: 15490540.

197: Samar VJ, Parasnis I. Non-verbal IQ is correlated with visual field advantages for short duration coherent motion detection in deaf signers with varied ASL exposure and etiologies of deafness. Brain Cogn. 2007 Dec;65(3):260-9. Epub 2007 Jun 14. PubMed PMID: 17574715.

198: Snowling MJ. Specific disorders and broader phenotypes: the case of dyslexia. Q J Exp Psychol (Colchester). 2008 Jan;61(1):142-56. Review. PubMed PMID: 18038345.

199: Stein J. The neurobiology of reading difficulties. Prostaglandins Leukot Essent Fatty Acids. 2000 Jul-Aug;63(1-2):109-16. Review. PubMed PMID: 10970722.

200: Vermeulen AM, van Bon W, Schreuder R, Knoors H, Snik A. Reading comprehension of deaf children with cochlear implants. J Deaf Stud Deaf Educ. 2007 Summer;12(3):283-302. Epub 2007 May 30. PubMed PMID: 17537924.

201: Enns C, Lafond LD. Reading against all odds: a pilot study of two deaf students with dyslexia. Am Ann Deaf. 2007 Spring;152(1):63-72. PubMed PMID: 17642365.

202: Zacks JM, Speer NK, Reynolds JR. Segmentation in reading and film comprehension. J Exp Psychol Gen. 2009 May;138(2):307-27. PubMed PMID: 19397386.

203: Williams A. The relationship between two visual communication systems: reading and lipreading. J Speech Hear Res. 1982 Dec;25(4):500-3. PubMed PMID: 7162149.

204: Hawelka S, Wimmer H. Visual target detection is not impaired in dyslexic readers. Vision Res. 2008 Mar;48(6):850-2. Epub 2008 Jan 4. PubMed PMID: 18177914.

205: Irausquin RS, Drent J, Verhoeven L. Benefits of computer-presented speed training for poor readers. Ann Dyslexia. 2005 Dec;55(2):246-65. PubMed PMID: 17849195.

206: Castelo-Branco M, Mendes M, Silva F, Massano J, Januário G, Januário C, Freire A. Motion integration deficits are independent of magnocellular impairment in Parkinson's disease. Neuropsychologia. 2009 Jan;47(2):314-20. Epub 2008 Sep 7. PubMed PMID: 18822307.

207: Skottun BC, Parke LA. The possible relationship between visual deficits and dyslexia: examination of a critical assumption. J Learn Disabil. 1999 Jan-Feb;32(1):2-5. PubMed PMID: 15499883.

208: Mason M, Katz L. Visual processing of nonlinguistic strings: redundancy effects and reading ability. J Exp Psychol Gen. 1976 Dec;105(4):338-48. PubMed PMID: 1003121.

209: Lassus-Sangosse D, N'guyen-Morel MA, Valdois S. Sequential or simultaneous visual processing deficit in developmental dyslexia? Vision Res. 2008 Mar;48(8):979-88. Epub 2008 Mar 10. PubMed PMID: 18331749.

210: Kirby JR, Silvestri R, Allingham BH, Parrila R, La Fave CB. Learning strategies and study approaches of postsecondary students with dyslexia. J Learn Disabil. 2008 Jan-Feb;41(1):85-96. PubMed PMID: 18274505.

211: Denton CA, Fletcher JM, Anthony JL, Francis DJ. An evaluation of intensive intervention for students with persistent reading difficulties. J Learn Disabil. 2006 Sep-Oct;39(5):447-66. PubMed PMID: 17004676.

212: Powers M, Grisham D, Riles P. Saccadic tracking skills of poor readers in high school. Optometry. 2008 May;79(5):228-34. PubMed PMID: 18436162.

213: Chung KK, McBride-Chang C, Wong SW, Cheung H, Penney TB, Ho CS. The role of visual and auditory temporal processing for Chinese children with developmental dyslexia. Ann Dyslexia. 2008 Jun;58(1):15-35. Epub 2008 May 16. PubMed PMID: 18483866.

214: Chang SQ, Williams RL, McLaughlin TF. Differential effects of oral reading to improve comprehension with severe learning disabled and educable mentally handicapped students. Adolescence. 1983 Fall;18(71):619-26. PubMed PMID: 6650272.

215: Nandakumar K, Leat SJ. Dyslexia: a review of two theories. Clin Exp Optom. 2008 Jul;91(4):333-40. Epub 2008 Jul 1. Review. PubMed PMID: 18430036.

216: Edwards VT, Hogben JH, Clark CD, Pratt C. Effects of a red background on magnocellular functioning in average and specifically disabled readers. Vision Res. 1996 Apr;36(7):1037-45. PubMed PMID: 8736262.

217: Andreassen AB, Knivsberg AM, Niemi P. Resistant readers 8 months later: energizing the student's learning milieu by targeted counselling. Dyslexia. 2006 May;12(2):115-33. PubMed PMID: 16734355.

218: Das JP, Bisanz GL, Mancini G. Performance of good and poor readers on cognitive tasks: changes with development and reading competence. J Learn Disabil. 1984 Nov;17(9):549-55. PubMed PMID: 6502013.

219: Kelly LP. The importance of processing automaticity and temporary storage capacity to the differences in comprehension between skilled and less skilled college-age deaf readers. J Deaf Stud Deaf Educ. 2003 Summer;8(3):230-49. PubMed PMID: 15448051.

220: Wallace MT. Dyslexia: bridging the gap between hearing and reading. Curr Biol. 2009 Mar 24;19(6):R260-2. PubMed PMID: 19321145.

221: Leonard CM, Kuldau JM, Maron L, Ricciuti N, Mahoney B, Bengtson M, DeBose C. Identical neural risk factors predict cognitive deficit in dyslexia and schizophrenia. Neuropsychology. 2008 Mar;22(2):147-58. PubMed PMID: 18331156.

222: Katz LA, Carlisle JF. Teaching students with reading difficulties to be close readers: a feasibility study. Lang Speech Hear Serv Sch. 2009 Jul;40(3):325-40. PubMed PMID: 19564445.

223: Noble KG, McCandliss BD. Reading development and impairment: behavioral, social, and neurobiological factors. J Dev Behav Pediatr. 2005 Oct;26(5):370-8. Review. PubMed PMID: 16222178.

224: Saldaña D, Carreiras M, Frith U. Orthographic and phonological pathways in hyperlexic readers with Autism Spectrum Disorders. Dev Neuropsychol. 2009;34(3):240-53. PubMed PMID: 19437201.

225: La Rocque CL, Visser TA. Sequential object recognition deficits in normal readers. Vision Res. 2009 Jan;49(1):96-101. Epub 2008 Nov 18. PubMed PMID: 18940192.

226: Maughan B, Messer J, Collishaw S, Pickles A, Snowling M, Yule W, Rutter M. Persistence of literacy problems: spelling in adolescence and at mid-life. J Child Psychol Psychiatry. 2009 Aug;50(8):893-901. Epub 2009 Mar 31. PubMed PMID: 19490310.

227: Lee LW. Development and validation of a reading-related assessment battery in Malay for the purpose of dyslexia assessment. Ann Dyslexia. 2008 Jun;58(1):37-57. Epub 2008 Feb 22. PubMed PMID: 18293088.

228: Pellicano E, Gibson LY. Investigating the functional integrity of the dorsal visual pathway in autism and dyslexia. Neuropsychologia. 2008 Aug;46(10):2593-6. Epub 2008 Apr 20. PubMed PMID: 18501932.

229: Grisham D, Powers M, Riles P. Visual skills of poor readers in high school. Optometry. 2007 Oct;78(10):542-9. PubMed PMID: 17904495.

230: Watt SE, Shores A, North KN. An examination of lexical and sublexical reading skills in children with neurofibromatosis type 1. Child Neuropsychol. 2008 Sep;14(5):401-18. Erratum in: Child Neuropsychol. 2008 Sep;14(5):482. PubMed PMID: 17963094.

231: Miller P. Reading experience and changes in the processing of letters, written words, and pseudohomophones: comparing fifth-grade students and university students. J Genet Psychol. 2005 Dec;166(4):407-34. PubMed PMID: 16463606.

232: Krischer CC, Zangemeister WH. Scanpaths in reading and picture viewing: computer-assisted optimization of display conditions. Comput Biol Med. 2007 Jul;37(7):947-56. Epub 2007 Mar 23. Review. PubMed PMID: 17362903.

233: Czepita D, Lodygowska E. [Role of the organ of vision in the course of developmental dyslexia]. Klin Oczna. 2006;108(1-3):110-3. Review. Polish. PubMed PMID: 16883955.

234: Skottun BC. The magnocellular deficit theory of dyslexia: the evidence from contrast sensitivity. Vision Res. 2000;40(1):111-27. Review. PubMed PMID: 10768046.

235: Douglas G, Grimley M, McLinden M, Watson L. Reading errors made by children with low vision. Ophthalmic Physiol Opt. 2004 Jul;24(4):319-22. PubMed PMID: 15228509.

236: Putnam LR. Minnesota Percepto-Diagnostic Test and reading achievement. Percept Mot Skills. 1981 Aug;53(1):235-8. PubMed PMID: 7290871.

237: Egidi G, Gerrig RJ. Readers' experiences of characters' goals and actions. J Exp Psychol Learn Mem Cogn. 2006 Nov;32(6):1322-9. PubMed PMID: 17087586.

238: Skottun BC, Skoyles JR. Some remarks on the use of motion VEPs to assess magnocellular sensitivity. Clin Neurophysiol. 2004 Dec;115(12):2834-6; author reply 2836-8. PubMed PMID: 15546791.

239: Clifton-Everest IM. The immediate recognition of tachistoscopically presented visual patterns by backward readers. Genet Psychol Monogr. 1974 May;89(2):221-39. PubMed PMID: 4836292.

240: Levy T, Walsh V, Lavidor M. Dorsal stream modulation of visual word recognition in skilled readers. Vision Res. 2010 Apr 21;50(9):883-8. Epub 2010 Feb 24. PubMed PMID: 20188122.

241: Metzger RL, Werner DB. Use of visual training for reading disabilities: a review. Pediatrics. 1984 Jun;73(6):824-9. Review. PubMed PMID: 6374600.

242: Preston MS, Guthrie JT, Kirsch I, Gertman D, Childs B. VERs in normal and disabled adult readers. Psychophysiology. 1977 Jan;14(1):8-14. PubMed PMID: 834808.

243: Garrison W, Dowaliby F, Long G. Reading comprehension test item difficulty as a function of cognitive processing variables. Am Ann Deaf. 1992 Mar;137(1):22-30. PubMed PMID: 1605095.

244: Taylor KE, Richardson AJ. Visual function, fatty acids and dyslexia. Prostaglandins Leukot Essent Fatty Acids. 2000 Jul-Aug;63(1-2):89-93. Review. PubMed PMID: 10970719.

245: SANTOSTEFANO S. COGNITIVE CONTROLS AND EXCEPTIONAL STATES IN CHILDREN. J Clin Psychol. 1964 Apr;20:213-8. PubMed PMID: 14142931.

246: SANTOSTEFANO S. COGNITIVE CONTROLS AND EXCEPTIONAL STATES IN CHILDREN. J Clin Psychol. 1964 Apr;20:213-8. PubMed PMID: 14140081.

247: Williams MC, May JG. On a failure to replicate: methodologically close, but not close enough. A response to hogben et al. Vision Res. 1996 May;36(10):1509-11. PubMed PMID: 8762768.

248: Fox AB, Rosen J, Crawford M. Distractions, distractions: does instant messaging affect college students' performance on a concurrent reading comprehension task? Cyberpsychol Behav. 2009 Feb;12(1):51-3. PubMed PMID: 19006461.

249: Patching GR, Jordan TR. Assessing the role of different spatial frequencies in word perception by good and poor readers. Mem Cognit. 2005 Sep;33(6):961-71. PubMed PMID: 16496718.

250: Al-Hilawani YA. Visual analyses and discriminations: one approach to measuring students' metacognition. Am Ann Deaf. 2006 Spring;151(1):16-24. PubMed PMID: 16856642.

251: Colby D, Laukkanen HR, Yolton RL. Use of the Taylor Visagraph II system to evaluate eye movements made during reading. J Am Optom Assoc. 1998 Jan;69(1):22-32. PubMed PMID: 9479933.

252: Fletcher J, Martinez G. An eye-movement analysis of the effects of scotopic sensitivity correction on parsing and comprehension. J Learn Disabil. 1994 Jan;27(1):67-70. PubMed PMID: 8133190.

253: Victor JD. Defective visual pathway in reading-disabled children. N Engl J Med. 1993 Aug 19;329(8):579. PubMed PMID: 8336762.

254: Salmerón L, Kintsch W, Cañas JJ. Reading strategies and prior knowledge in learning from hypertext. Mem Cognit. 2006 Jul;34(5):1157-71. PubMed PMID: 17128614.

255: Hiatt RL. Reading problems and the ophthalmologist. Ann Ophthalmol. 1984 Feb;16(2):116-22. PubMed PMID: 6703583.

256: Solan HA. Eye movement problems in achieving readers: an update. Am J Optom Physiol Opt. 1985 Dec;62(12):812-9. PubMed PMID: 4083325.

257: Vellutino FR, Scanlon DM, Lyon GR. Differentiating between difficult-to-remediate and readily remediated poor readers: more evidence against the IQ-achievement discrepancy definition of reading disability. J Learn Disabil. 2000 May-Jun;33(3):223-38. Review. PubMed PMID: 15505962.

258: Kelly L. Using silent motion pictures to teach complex syntax to adult deaf readers. J Deaf Stud Deaf Educ. 1998 Summer;3(3):217-30. PubMed PMID: 15579865.

259: Rattan G, Dean RS, Lowrie RE. Inducing comprehension in the bilateral poor reader. Int J Neurosci. 1987 Sep;36(1-2):67-73. PubMed PMID: 3654093.

260: Shorr RH, Svagr VB. Relationship of perceptual and visual skills with reading accuracy and comprehension. J Am Optom Assoc. 1966 Jul;37(7):671-7. PubMed PMID: 5945043.

261: Williams MC, Lecluyse K, Rock-Faucheux A. Effective interventions for reading disability. J Am Optom Assoc. 1992 Jun;63(6):411-7. PubMed PMID: 1378860.

262: Beery JW. Matching of auditory and visual stimuli by average and retarded readers. Child Dev. 1967 Sep;38(3):827-33. PubMed PMID: 6049644.

263: Galaburda AM, Duchaine BC. Developmental disorders of vision. Neurol Clin. 2003 Aug;21(3):687-707. Review. PubMed PMID: 13677818.

264: Skottun BC, Skoyles J. Yellow filters, magnocellular responses, and reading. Int J Neurosci. 2007 Feb;117(2):287-93. Review. PubMed PMID: 17365114.

265: Ramus F. Dyslexia. Talk of two theories. Nature. 2001 Jul 26;412(6845):393-5. PubMed PMID: 11473297.

266: Sidman M, Willson-Morris M. Testing for reading comprehension: a brief report on stimulus control. J Appl Behav Anal. 1974 Summer;7(2):327-32. PubMed PMID: 4436180; PubMed Central PMCID: PMC1311971.

267: Kastner SB, Rickards C. Mediated memory with novel and familiar stimuli in good and poor readers. J Genet Psychol. 1974 Mar;124(1st Half):105-13. PubMed PMID: 4823572.

268: Mitterer JO. There are at least two kinds of poor readers: whole-word poor readers and recoding poor readers. Can J Psychol. 1982 Sep;36(3):445-61. PubMed PMID: 7172130.

269: LeCluyse K, Williams MC, Rock-Faucheux A. Specific reading disability in children: etiology, diagnosis and intervention. Compr Ther. 1991 Oct;17(10):3-6. PubMed PMID: 1764893.

270: Carter JL, Diaz A. Effects of visual and auditory background on reading test performance. Except Child. 1971 Sep;38(1):43-50. PubMed PMID: 5095191.

271: Graesser AC, Lu S, Olde BA, Cooper-Pye E, Whitten S. Question asking and eye tracking during cognitive disequilibrium: comprehending illustrated texts on devices when the devices break down. Mem Cognit. 2005 Oct;33(7):1235-47. PubMed PMID: 16532856.

272: Chase C, Stein J. Visual magnocellular deficits in dyslexia. Brain. 2003 Sep;126(Pt 9):E2; author reply E3. PubMed PMID: 12937067.

273: Ahmed M, Dutton GN. Cognitive visual dysfunction in a child with cerebral damage. Dev Med Child Neurol. 1996 Aug;38(8):736-9. PubMed PMID: 8761169.

274: Wheldall K, Limbrick L. Do More Boys Than Girls Have Reading Problems? J Learn Disabil. 2010 Apr 7. [Epub ahead of print] PubMed PMID: 20375293.

275: Murray WS, Kennedy A. Spatial coding in the processing of anaphor by good and poor readers: evidence from eye movement analyses. Q J Exp Psychol A. 1988 Nov;40(4):693-718. PubMed PMID: 3212210.
276: GOETZINGER CP, DIRKS DD, BAER CJ. Auditory discrimination and visual perception in good and poor readers. Ann Otol Rhinol Laryngol. 1960 Mar;69:121-36. PubMed PMID: 13850454.

277: Muñoz B, Magliano JP, Sheridan R, McNamara DS. Typing versus thinking aloud when reading: implications for computer-based assessment and training tools. Behav Res Methods. 2006 May;38(2):211-7. PubMed PMID: 16956096.

278: Young AW, Ellis AW. Asymmetry of cerebral hemispheric function in normal and poor readers. Psychol Bull. 1981 Jan;89(1):183-90. PubMed PMID: 7232610.

279: Lubkin V. The ophthalmologist and the reading problem. Bull N Y Acad Med. 1968 Apr;44(4):459-69. PubMed PMID: 5241254; PubMed Central PMCID: PMC1750135.

280: Eden G, Zeffiro T. The possible relationship between visual deficits and dyslexia. J Learn Disabil. 1999 Sep-Oct;32(5):378. PubMed PMID: 15510426.

281: Bakker DJ. Sensory dominance in normal and backward readers. Percept Mot Skills. 1966 Dec;23(3):1055-8. PubMed PMID: 5972892.

282: Wallbrown FH, Blaha J, Wherry RJ Sr, Counts DH. An empirical test of Myklebust's cognitive structure hypotheses for 70 reading-disabled children. J Consult Clin Psychol. 1974 Apr;42(2):211-8. PubMed PMID: 4823556.

283: Smith W. The visual system in reading and learning disabilities. J Sch Health. 1969 Feb;39(2):144-50. PubMed PMID: 5190642.

284: Walczyk JJ, Kelly KE, Meche SD, Braud H. Time Limitations Enhance Reading Comprehension. Contemp Educ Psychol. 1999 Apr;24(2):156-165. PubMed PMID: 10072314.

285: Bodovitz S. Consciousness is discontinuous: the perception of continuity requires conscious vectors and needs to be balanced with creativity. Med Hypotheses. 2004;62(6):1003-5. PubMed PMID: 15142664.

286: Katz L, Wicklund DA. Letter scanning rate for good and poor readers in grades two and six. J Educ Psychol. 1972 Aug;63(4):363-7. PubMed PMID: 5046576.

287: Krippner S. Scores made by retarded readers on the Holtzman Inkblot Technique. Percept Mot Skills. 1971 Dec;33(3):1089-90. PubMed PMID: 5160021.

288: Hollis J, Allen PM. Screening for Meares-Irlen sensitivity in adults: can assessment methods predict changes in reading speed? Ophthalmic Physiol Opt. 2006 Nov;26(6):566-71. PubMed PMID: 17040420.

289: Skottun BC, Skoyles JR. The early part of the visual system--from the retina to the visual cortex--contains two parallel streams: the magnocellular and parvocellular systems. J Learn Disabil. 2005 Sep-Oct;38(5):386. PubMed PMID: 16329439.

290: Pezdek K, Simon S, Stoeckert J, Kiely J. Individual differences in television comprehension. Mem Cognit. 1987 Sep;15(5):428-35. PubMed PMID: 3670061.

291: Pickering MJ, McElree B, Traxler MJ. The difficulty of coercion: a response to de Almeida. Brain Lang. 2005 Apr;93(1):1-9. PubMed PMID: 15766763.

292: Skottun BC, Skoyles JR. L- and M-cone ratios and magnocellular sensitivity in reading. Int J Neurosci. 2010 Apr;120(4):241-4. PubMed PMID: 20374069.

293: Masson ME, Angell LS. Cognitive resource demands of reading normal and transformed typography. Can J Psychol. 1983 Jun;37(2):243-57. PubMed PMID: 6616339.

294: Richardson E, DiBenedetto B, Christ A, Press M. Relationship of auditory and visual skills to reading retardation. J Learn Disabil. 1980 Feb;13(2):77-82. PubMed PMID: 7391679.

295: Croucher PH. Vision and learning to read. Clin Exp Optom. 2002 Mar;85(2):112-3. PubMed PMID: 11952410.

296: BIRCH HG, BELMONT L. AUDITORY-VISUAL INTEGRATION IN NORMAL AND RETARDED READERS. Am J Orthopsychiatry. 1964 Oct;34:852-61. PubMed PMID: 14220514.

297: Robinson BN. A study of visual function in institutionalized juveniles who are demonstrated underachieving readers. Am J Optom Arch Am Acad Optom. 1973 Feb;50(2):113-6. PubMed PMID: 4511861.

298: Kavale K. Meta-analysis of the relationship between visual perceptual skills and reading achievement. J Learn Disabil. 1982 Jan;15(1):42-51. PubMed PMID: 7069285.

299: Gorman C. The new science of dyslexia. Time. 2003 Jul 28;162(4):52-9. PubMed PMID: 14974204.

300: Veitch JA, McColl SL. A critical examination of perceptual and cognitive effects attributed to full-spectrum fluorescent lighting. Ergonomics. 2001 Feb 20;44(3):255-79. Review. Erratum in: Ergonomics 2001 Mar 15;44(4):473. PubMed PMID: 11219759.

301: SILVER AA, HAGIN RA. SPECIFIC READING DISABILITY: FOLLOW-UP STUDIES. Am J Orthopsychiatry. 1964 Jan;34:95-102. PubMed PMID: 14111421.

302: Holmes BC. The effects of a strategy and sequenced materials on the inferential comprehension of disabled readers. J Learn Disabil. 1985 Nov;18(9):542-6. PubMed PMID: 4067413.

303: Payne MC Jr, Davenport RK, Domangue JC, Soroka RD. Reading comprehension and perception of sequentially organized patterns: intramodal and cross-modal comparisons. J Learn Disabil. 1980 Jan;13(1):39-44. PubMed PMID: 7373145.

304: Jarvella RJ, Lundberg I. Visual constraints in reading: evidence from non-ocular behaviour. Scand J Psychol. 1987;28(2):93-103. PubMed PMID: 3685919.

305: Heazlett M, Whaley RF. The common cold: its effects on perceptual ability and reading comprehension among pupils of a seventh-grade class. J Sch Health. 1976 Mar;46(3):145-7. PubMed PMID: 1044936.

306: McMonnies C. Vision and learning to read. Clin Exp Optom. 2002 Mar;85(2):112. PubMed PMID: 11952409.

307: Jenkins JR, Heliotis JD, Stein ML, Haynes MC. Improving reading comprehension by using paragraph restatements. Except Child. 1987 Sep;54(1):54-9. PubMed PMID: 3653217.

308: Bundesen C, Larsen A. Vision and visual cognition. Psychol Res. 1999;62(2-3):79-80. PubMed PMID: 10472195.

309: Pennington BF. Using genetics to dissect cognition. Am J Hum Genet. 1997 Jan;60(1):13-6. PubMed PMID: 8981941; PubMed Central PMCID: PMC1712539.

310: Oakan R, Wiener M, Cromer W. Identification, organization, and reading comprehension for good and poor readers. J Educ Psychol. 1971 Feb;62(1):71-8. PubMed PMID: 5100137.

311: Siegel LS, Smythe IS. Reflections on research on reading disability with special attention to gender issues. J Learn Disabil. 2005 Sep-Oct;38(5):473-7. PubMed PMID: 16329447.

312: Siegel AI, Lautman MR, Burkett JR. Reading grade level adjustment and auditory supplementation as techniques for increasing textual comprehensibility. J Educ Psychol. 1974 Dec;66(6):895-902. PubMed PMID: 4443475.

313: Rosen CL. An investigation of perceptual training and reading achievement in first grade. Am J Optom Arch Am Acad Optom. 1968 May;45(5):322-32. PubMed PMID: 5245519.

314: Kaye G. Vision and learning to read. Clin Exp Optom. 2002 Mar;85(2):111. PubMed PMID: 11952408.

315: Harrison AG, Edwards MJ, Armstrong I, Parker KC. An investigation of methods to detect feigned reading disabilities. Arch Clin Neuropsychol. 2010 Mar;25(2):89-98. Epub 2010 Jan 10. PubMed PMID: 20064815.

316: Starnes DR. Visual abilities vs reading abilities. J Am Optom Assoc. 1969 Jun;40(6):596-600. PubMed PMID: 5789177.

317: JAMPOLSKY A. The problem of the poor reader. Calif Med. 1951 Apr;74(4):230-2. PubMed PMID: 14821815; PubMed Central PMCID: PMC1520873.

318: WAITES L. Dyslexia, a form of visual imperception in children. Tex State J Med. 1963 Mar;59:196-8. PubMed PMID: 13998340.

319: Haith MM, Kessen W, Collins D. Response of the human infant to level of complexity of intermittent visual movement. J Exp Child Psychol. 1969 Feb;7(1):52-69. PubMed PMID: 5777822.

320: McRae SG. Sequential-simultaneous processing and reading skills in primary grade children. J Learn Disabil. 1986 Oct;19(8):509-11. PubMed PMID: 3760706.

321: Bonsall C, Dornbush RL. Visual perception and reading ability. J Educ Psychol. 1969 Aug;60(4):294-9. PubMed PMID: 5811796.

322: Calfee RC, Jameson P. Visual search and reading. J Educ Psychol. 1971 Dec;62(6):501-5. PubMed PMID: 5130023.

323: TUCKMAN E. THE FAMILIES OF BACKWARD READERS. Practitioner. 1965 Feb;194:280. PubMed PMID: 14259719.

324: Lahey BB, McNees MP, Brown CC. Modification of deficits in reading for comprehension. J Appl Behav Anal. 1973 Fall;6(3):475-480. PubMed PMID: 16795430; PubMed Central PMCID: PMC1310860.

325: TERRACE HS. The effects of retinal and attention on the perception of words. J Exp Psychol. 1959 Nov;58:382-5. PubMed PMID: 13837486.

326: SMITH W. Procedure in visual training-X. Anomalies of reading, comprehension and learning. Opt J Rev Optom. 1950 Oct 15;87(20):40; passim; contd. PubMed PMID: 14785922.

327: Skottun BC. The magnocellular deficit theory of dyslexia. Trends Neurosci. 1997 Sep;20(9):397-8. PubMed PMID: 9292967.

328: Lacert P. [Clinical and functional evaluation of a person with a motor, cognitive or sensory handicap]. Rev Prat. 2004 Oct 31;54(16):1821-7, 1835. French. PubMed PMID: 15630890.

329: Higgins N, Gage G. Perceptual mode and reading improvement of college students. Percept Mot Skills. 1968 Jun;26(3):Suppl:1249+. PubMed PMID: 5675696.

330: FULLER GB, SHAW CR. Visual orientation in reading disability: diagnostic considerations. J Am Acad Child Psychiatry. 1963 Jul;2:484-94. PubMed PMID: 13960228.

331: Kulinsky L, Stoyanov I. The contribution of basketball to the development of some psychological qualities of professional relevance. Folia Med (Plovdiv). 1981;23(2):63-6. PubMed PMID: 6804330.

332: HARTLAGE LC. LISTENING COMPREHENSION IN THE RETARDED BLIND. Percept Mot Skills. 1965 Jun;20:763-4. PubMed PMID: 14313990.

333: FREEBURNE CM. Laws of learning, visual perception and the reading process. Am J Optom Arch Am Acad Optom. 1961 Mar;38:161-72. PubMed PMID: 13701590.

334: STEINBAUM M, KURK M. Relationship between the Keystone visual skills tests with reading achievement and intelligence. Am J Optom Arch Am Acad Optom. 1958 Apr;35(4):173-81. PubMed PMID: 13520901.

335: Glenberg AM, Epstein W. Inexpert calibration of comprehension. Mem Cognit. 1987 Jan;15(1):84-93. PubMed PMID: 3821493.

336: Epstein W, Glenberg AM, Bradley MM. Coactivation and comprehension: contribution of text variables to the illusion of knowing. Mem Cognit. 1984 Jul;12(4):355-60. PubMed PMID: 6503698.

337: WALTERS RH, DOAN H. Perceptual and cognitive functioning of retarded readers. J Consult Psychol. 1962 Aug;26:355-61. PubMed PMID: 14004786.

338: Pierson WR. Night vision and mild hypoxia. Aerosp Med. 1967 Oct;38(10):993-4. PubMed PMID: 6053170.

339: SILVERSTEIN AB. VARIANCE COMPONENTS IN THE DEVELOPMENTAL TEST OF VISUAL PERCEPTION. Percept Mot Skills. 1965 Jun;20:973-6. PubMed PMID: 14314024.

340: KOLSON CJ, ATKINSON A. Information the educator should supply the visual specialist to assist him in caring for non-achievers. Am J Optom Arch Am Acad Optom. 1962 Apr;39:211-20. PubMed PMID: 14458083.

341: BUTLER RA, WOOLPY JH. Visual attention in the rhesus monkey. J Comp Physiol Psychol. 1963 Apr;56:324-8. PubMed PMID: 14017380.

342: BARGER WC, LAVIN R, SPEIGHT FE. Constitutional aspects in psychiatry of poor readers. Dis Nerv Syst. 1957 Aug;18(8):289-94. PubMed PMID: 13447806.

343: HUELSMAN CB. Some recent research on visual problems in reading. Am J Optom Arch Am Acad Optom. 1958 Nov;35(11):559-64. PubMed PMID: 13595081.

344: NEISSER U, LAZAR R. SEARCHING FOR NOVEL TARGETS. Percept Mot Skills. 1964 Oct;19:427-32. PubMed PMID: 14214709.

345: THOMSON A, SMITH BB. Effect of attention in peripheral vision. Nature. 1961 Aug 12;191:732-3. PubMed PMID: 13776639.

346: MOWBRAY GH. Simultaneous vision and audition: the comprehension of prose passages with varying levels of difficulty. J Exp Psychol. 1953 Nov;46(5):365-72. PubMed PMID: 13109141.

347: SCHUCKMAN H. Attention and visual threshold. Am J Optom Arch Am Acad Optom. 1963 May;40:284-91. PubMed PMID: 13987130.

348: ALTUS GT. A WISC profile for retarded readers. J Consult Psychol. 1956 Apr;20(2):155-6. PubMed PMID: 13306849.

349: MURROUGHS TR. Retarded readers and optometry. Am J Optom Arch Am Acad Optom. 1962 Jan;39:23-32. PubMed PMID: 14477497.

350: MICROFILMS and visual aids. Br J Phys Med. 1953 Mar;16(3):55-6. PubMed PMID: 13042037.

351: Skottun BC. Rats, dyslexia, and the magnocellular system. Cortex. 2010 Jun;46(6):799. Epub 2010 Jan 15. PubMed PMID: 20138264.

352: Stein J, Talcott J, Walsh V V. Controversy about the visual magnocellular deficit in developmental dyslexics. Trends Cogn Sci. 2000 Jun;4(6):209-211. PubMed PMID: 10827442.

353: FRAISSE P, VOILLAUME C. [Comprehension capacity, attention level and block of alpha rhythm.]. Annee Psychol. 1961;61:51-7. French. PubMed PMID: 13894449.

354: DICKINSON TH. Illuminated box for reading sensitivity tests. Treat Serv Bull. 1954 Feb;9(2):59-60. PubMed PMID: 13146817.

355: DAVIS GW. Techniques of visual enhancement. Optom Wkly. 1949 Oct 20;40(42):1601; passim. PubMed PMID: 15395808.

356: CHURCHILL AV. A comparison of tactual and visual interpolation. Can J Psychol. 1959 Mar;13(1):23-7. PubMed PMID: 13629397.

357: ROUGEUL MB, BUSER P. [Data on the topography of the visual projection sin the brain of the pigeon.]. C R Seances Soc Biol Fil. 1953 Nov;147(21-22):1750-3. Undetermined Language. PubMed PMID: 13150670.

358: SHKOL'NIK-IARROS EG. [Morphology of the visual analysor.]. Zh Vyssh Nerv Deiat Im I P Pavlova. 1954 Mar-Apr;4(2):289-304. Russian. PubMed PMID: 13217448.

359: Funnell HS. Appeal to Readers. Can Vet J. 1976 May;17(5):143. PubMed PMID: 17422009; PubMed Central PMCID: PMC1697249.