Research update on Visually-Based Reading Disability

Barry Tannen, O.D., FCOVD

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
University Laboratory of Physiology, Oxford OX1 3PT, UK. j.stein@physiol.ox.ac.uk

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
University Laboratory of Physiology, Department of Orthoptics, Royal Berkshire Hospital, Reading, UK. john.stein@physio.ox.ac.uk

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
Department of Psychology, University College London, Gower Street, London WC1E 6BT, UK. a.johnston@ucl.ac.uk

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
Department of Optometry & Vision Sciences, University of Melbourne, Parkville, Vic 3010, Australia. trv@unimelb.edu.au

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 Institiue for Vision Research, State College of Optometry, State University of New York 10036, USA.
hsolan@sunyopt.edu

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.
School of Psychology, The Australian National University, Canberra, Australia. Alison.Kevan@anu.edu.au

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.
Southern California College of Optometry, Fullerton, California 92831, USA. wridder@scco.edu

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.