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Case Report

Improvements in performance following optometric vision therapy in a child with dyspraxia

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Abstract

SS, an 8-year-old boy with dyspraxia, presented for behavioural optometry assessment. He had been diagnosed with a subtle form of dyspraxia by his paediatric occupational therapist, based on poor proprioception, delayed bilateral integration and poor visual perception. A full visual assessment was carried out. SS was given a programme of reflex inhibition exercises for 3 months. Then, a programme of optometric vision therapy (OVT) exercises was prescribed at home and in practice for a period of 8 months. SS was assessed using a battery of occupational therapy Sensory Integration and Praxis Tests (SIPT) before optometric intervention, and after OVT. There were significant improvements in fusional reserves, accommodative facility and oculomotor control of pursuit and saccadic eye movements. His reading level had changed by 4 years in 11 months. The SIPT results showed improvements in the visual and motor/visual perception subtests, confirming the significant changes in visual perceptual performance. Consideration is given to treatment modalities for dyspraxia, and the studies confirming their effectivity of approach. This case study provides evidence supporting the use of OVT eye exercises in dyspraxia, ocular motility, accommodative dysfunction, learning difficulties and sports performance. The need for further research and inter-professional working is discussed.

Keywords: behavioural optometry, dyspraxia, occupational therapy, optometric vision therapy, Sensory Integration and Praxis Tests (SIPT)

Introduction

Patients often arrive for a behavioural optometry assessment with a history of reading difficulties, poor attainment at school, poor attention span, tiredness and frustration at their lack of success despite enormous effort. Previous assessments with optometrists, educational psychologists, paediatricians and occupational therapists are common. Many patients have diagnoses of specific learning difficulty, dyslexia or dyspraxia.

SS, a boy aged 8 years and 3 months, presented for assessment on 18 September 2002 with a diagnosis from his paediatric occupational therapist of a subtle form of dyspraxia. The diagnosis was based on poor proprioception, delayed bilateral integration and poor visual perception.

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Dyspraxia

Dyspraxia is a condition that comes under the umbrella term of specific learning difficulties (SLD). Figure 1 shows a breakdown of SLD, but a patient's individual diagnosis may depend on the health/educational practitioner making the assessment (Kirby, 1999). These learning difficulties are not exclusive, and a child may have several aspects to their SLD, e.g. dyslexia and dyspraxia.

Bundy *et al.* (2002) explained the following definitions: **(1)** Praxis means 'action based on will' and comes from the Greek word for 'doing, acting, deed and practice'. Praxis is primarily the planning of a motor act; it is a

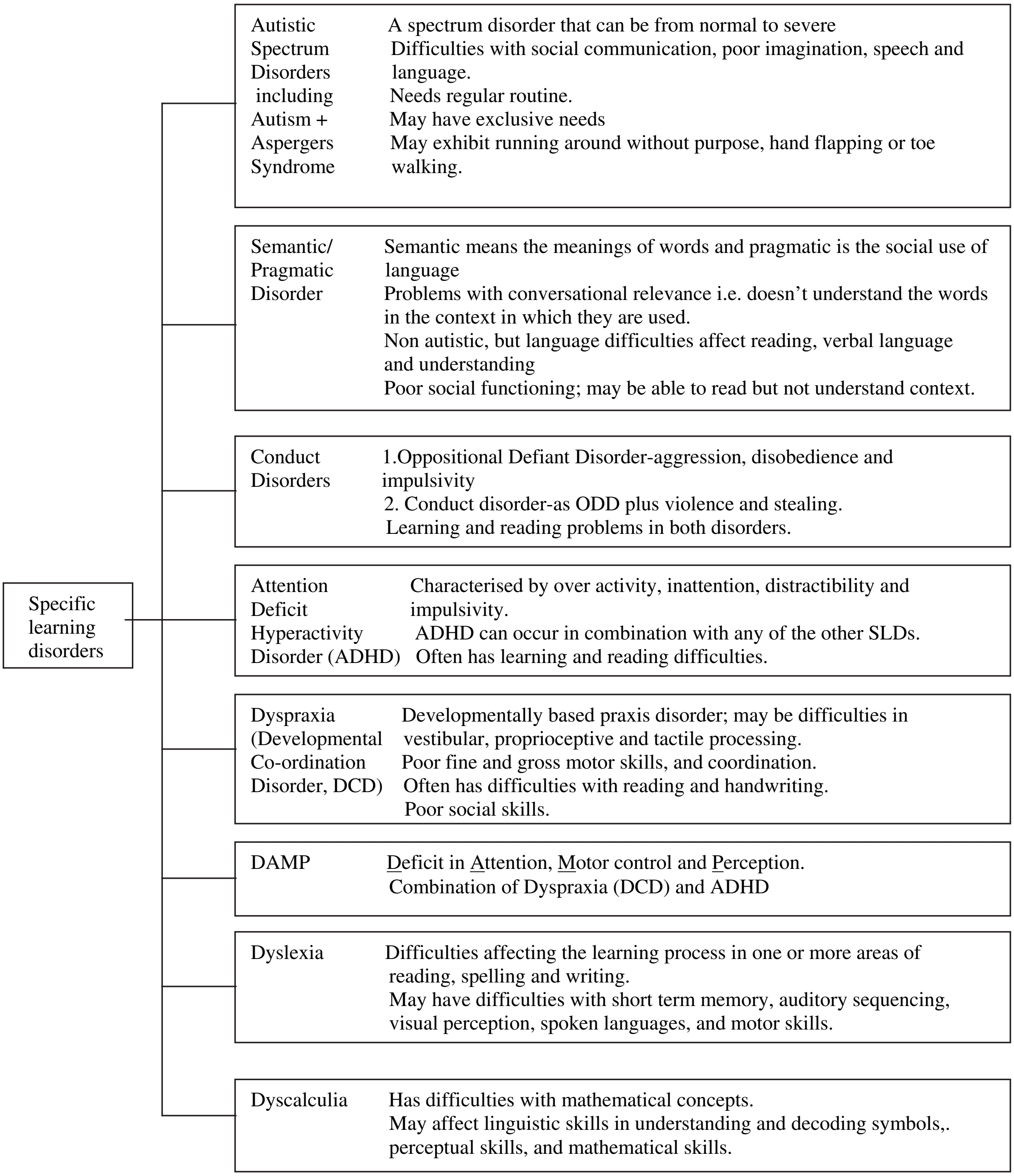

Figure 1. A breakdown of specific learning difficulties (SLD) into types. (Compiled from Kirby, 1999, and Millard, 2004.)

process that requires knowledge of action and objects, motivation and intention on the part of the person.
(2) Apraxia is the inability to perform learned actions, and impeded ability to learn a new action in the absence of paralysis, sensory loss or disturbance of muscle tone.
(3) Dyspraxia describes motor planning deficits that are developmental rather than acquired. Dyspraxia can also be called developmental coordination disorder (DCD).

Bundy *et al.* (2002) further classified dyspraxia as:
(1) Cortical – difficulties in cortical processing:
(a) Ideational – difficulties in conceptualising an action.
(b) On verbal command – difficulties in higher cortical function understanding the command.
(2) Sensory integration based dyspraxia – difficulties in sensory processing:
(a) Bilateral integration and sequencing (BIS) – deficits in vestibular and proprioceptive processing.
(b) Somato-dyspraxia – deficits in vestibular, proprioceptive and tactile processing.

In 1994 the prevalence of dyspraxia around the world was found to range from 2.7 to 15.6%, depending on the definitions and diagnosis criteria (Sugden and Wright, 1998). The mean figure appeared to be 5% with a further 10% 'at risk'. The UK figure was 10% (Sugden and Wright, 1998).

Portwood (1999) describes patients with dyspraxia as likely to show the following profile of early development:
(1) hyperactivity from birth;
(2) feeding difficulties, e.g. colic, lactose intolerance, poor weight gain;
(3) sleeping difficulties, e.g. awake every 2 h, night terrors;
(4) delayed development of motor milestones, e.g. late sitting, walking, and bottom shuffling rather than crawling;
(5) delayed acquisition of language.

There are several models in the development of coordination in children. Work by Gessell and Amatruda (1945), and McGraw (1943) established 'milestones' of development, e.g. sitting, crawling and walking. McGraw (1943) said that 'a certain amount of neural maturation must take place before any function can be modified by specific stimulation'. This suggests that there is a natural sequence of motor development with maturation, but this development is modified by behaviour and in response to environmental factors.

In 1979 Gibson's model (Gibson, 1979) suggested a direct perception approach to motor development, coupling perception and action without the need for cognitive processing. Although precise details of what 'direct' means are less clear, we believe that in this model the child perceives an event and then needs to perceive the potential actions in that particular environment. Thus, learning to move, and coordinate actions, involves learning the appropriate information sources, and what action possibilities are present, depending on the present action capabilities of the child. The child needs to make an active and determined exploration of an environment before making his/her assessments, and motor planning.

The key issue in dyspraxia is that children are unable to perform the required actions of daily living in a culturally acceptable way (Savelsbergh *et al.*, 2003). Many of the skill difficulties experienced in dyspraxia are shown below.

Children with dyspraxia may show:
(1) a continued misjudgement of distance and time, e.g. bumping into objects/people, failing to catch balls, etc.;
(2) an inability to coordinate complex movements to participate in age-related sports, e.g. running, kicking, catching and throwing;
(3) difficulties in manipulative skills, e.g. writing, copying, drawing, dressing and eating;
(4) low self-esteem and confidence;
(5) slow reaction times, and inefficient, poorly timed movements lacking in rhythm;
(6) poor physical fitness, and physically less active than children of the same age without motor difficulties;
(7) poor fitness can prevent optimal performance, thus compounding their movement difficulties;
(8) poor balance and postural control (Savelsbergh *et al.*, 2003).

Recent research (Kirby, 2005) links DCD with Joint Hypermobility Syndrome (JHS), as both conditions show similarities in the level and range of functional difficulties in fine and gross motor function, reading, spelling and socialisation. Research is continuing to consider the possibility that JHS is a subtype of DCD.

Losse *et al.* (1991) showed that children identified as clumsy at 6 years of age continued to have motor difficulties, as well as social, emotional and educational problems at 16 years of age. Dyspraxia (DCD) can therefore result in a life-long disability, persisting into adult life, rather than being considered simply a developmental motor delay that children eventually outgrow.

Bundy *et al.* (2002) recommended that children with sensory integration deficiencies with poor oculomotor skills could benefit from the systematic approach designed by a developmental optometrist who specialises in oculomotor training.

Optometric assessment

Before the behavioural visual assessment, SS and his parents were asked to complete a pre-assessment questionnaire; this formed a starting point for history and symptoms. SS found difficulties with:
(1) losing his place when reading, especially in the middle of the line;
(2) his handwriting, with poor use of the line, crowding the letters together, and often reversing his letters when writing;
(3) copying from the board, and often had help from his teacher at school;
(4) sequencing the days of the week and months of the year, and struggled with his multiplication tables; SS was unable to use graph paper;
(5) spellings, both difficult to learn and to use in his writing.

A routine refraction was carried out, without cycloplegia, and glasses were not prescribed. Ocular health was normal on ophthalmoscopy.

Unaided VA		Refraction	VA
6/7.5	RE	plano/−0.50×90	6/6
6/9	LE	−0.25/−0.25×60	6/6

The binocular investigation included:
(1) Cover test (Evans, 1997) noting direction and size of any deviation, and speed and quality of recovery, using a distance 6/9 letter and a near pen point as fixation targets.

(2) Motility (Evans, 1997) was assessed binocularly using a pen tip as a fixation target.
(3) Near point of convergence (Birnbaum, 1993) was measured using a small dot target on a Bernell occluder (Bemell, Mishowaka, IN, USA), and repeated three times.
(4) Distance and near phorias were measured using Howell distance and near phoria cards (Howell, 1991), and Maddox Rod and Wing (Evans, 1997).
(5) Aligning prism was measured at distance and near using Mallett fixation disparity units (Evans, 1997).
(6) AC/A measurements were made using a Howell near phoria chart (Howell, 1991), and the gradient method with +1.00DS and −1.00DS lenses.
(7) Fusional reserves were measured using a prism bar (Evans, 1997) with a 6/7.5 line of single letters as a distance target, and a line of N6 capital letters at near. The patient was asked to report blurring of the target, doubling of the target (break), and when single vision returned (recovery). The prism bar was moved after each report.
(8) Amplitude of accommodation (Birnbaum, 1993) was measured for RE and LE monocularly, and then binocularly, using the push up method in free space and an N5 word on the Bernell occluder. Amplitudes were measured three times and an average result recorded.
(9) Accommodative facility (Birnbaum, 1993) measures the flexibility of the accommodation system to exert and release accommodation by clearing vision during each cycle of a presentation of a +2.00DS lens followed by a −2.00DS lens. The accommodative facility measurement is recorded as the number of +2.00/−2.00 cycles that can be cleared in 1 min (cpm), and was repeated for RE, LE and binocularly.
(10) Reading level. The Maclure reading chart (Haag Streit UK, Harlow, UK) has age-related passages of N5–N14 sized print. It was used to assess SS's fluency of reading N5 print on progressively harder texts. To achieve each reading level SS had to read with basic fluency, i.e. complete the passage, but not necessarily understand the text or use expression. Observations were made on fluency of reading; use of finger/thumb to keep place; missing out words at the end of the line or in the middle; self-correction of mistakes; comprehension and effort involved. SS would then attempt the N5 passage of the next aged section of the Maclure reading chart until he found the text too difficult to read.
(11) Perception of physiological diplopia (BABO, 2003) was assessed using a single 6/19 distance letter and the right index finger.
(12) A Brock string (Press, 1997) was used to assess physiological diplopia awareness, near point of convergence, and stability of fixation.
(13) Oculomotor performance. A full visual assessment includes testing of the fine motor skills needed for ocular movements and binocular vision. Figure 2 shows how the fine motor control of binocular vision is dependent on the neural development of a child from primitive reflexes onwards.

(a) There are several methods of assessing eye movements within optometric practice, including the Maples Oculomotor Tests, and the Developmental Eye Movement test (DEM). The Maples Oculomotor Tests (Maples, 1995) assess a patient's ability to make and control pursuit movements following a single target, and saccades moving between two targets. The test is scored for ability to make the movement, accuracy of eye movement, and also the amount of head and body movement the patient made. Table 1 gives a breakdown of the scoring criteria.

The DEM (Garzia *et al*., 1990) compares the length of time taken to read 80 numbers arranged in lines vertically with the length of time taken to read the same 80 numbers arranged in lines horizontally.

Assessment of the vertical time determines the automaticity of number calling skills, and is a baseline performance affected by factors such as number recognition and retrieval, and visual–verbal integration time. Horizontal reading requires a sophisticated level of oculomotor control, but the time of the test will also be affected by the automaticity factors for vertical reading. The horizontal and vertical times are scored as a percentile ranking, i.e. a specific point in a distribution which has a given percentage of cases below it.

The ratio score compares horizontal time to vertical time (H/V), and a ratio score with a low percentile rank suggests difficulty with automaticity of number calling skills.

(b) Primitive reflexes are essential for the baby's survival in the first weeks of life, but should be inhibited or controlled by the higher centres of the brain by 6–8 months of age, to allow more sophisticated neural structures to develop, giving the child control of voluntary responses (Goddard, 1996). Prolonged primitive reflex activity may prevent the development of the succeeding postural reflexes, and if present beyond 6 months of age may result in immature patterns of behaviour (Goddard, 1996).

Retained primitive reflexes can interfere with:
(1) control of gross and fine motor skills including eye movements;
(2) kinaesthetic and proprioceptive senses;
(3) timing, rhythm and understanding of space and time;
(4) vestibular integration;
(5) visual perception (Reuterhall and Rasmussen, personal communication).

The primitive reflexes involved with visual development are the Moro, Tonic Labyrinthine Reflex (TLR), Spinal Galant, Asymmetrical Tonic Neck Reflex (ATNR) and Symmetrical Tonic Neck Reflex (STNR) (Reutenhall and Rasmussen, personal communication).

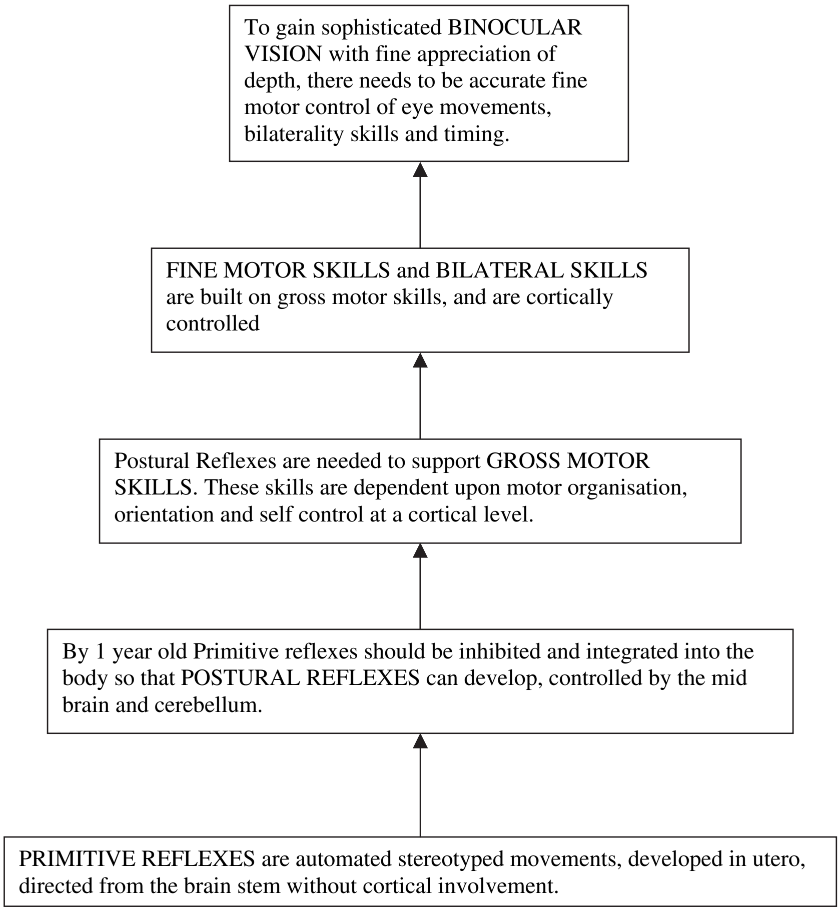

Figure 2. Hierarchy of neural development from primitive reflexes to binocular vision. (Compiled from Goddard, 1996, and Reutenhall and Rasmussen, personal communication)

Table 1. Scoring criteria for the Maples Eye Movement Tests (Maples, 1995)

	Pursuits	Saccades
Ability		
5	2 rotations in each direction	5 round trips between two targets
4	2 rotations in one direction + <2 in the other	4 round trips between two targets
3	1 rotation in each direction	3 round trips between two targets
2	1/2 rotation in each direction	2 round trips between two targets
1	<1/2 rotation in each direction	<2 round trips between two targets
Accuracy		
5	No re-fixations	No over- or under-shoots
4	2 or less re-fixations	Intermittent slight over- or under-shoots <50% of the time
3	3 or 4 re-fixations	Constant slight >50% of the time
2	5–10 re-fixations	Moderate one or more times
1	>10 re-fixations	Large one or more times
Head and body movements		
5	No movement	
4	Intermittent slight movements <50% of the time	
3	Constant slight movements >50% of the time	
2	Moderate movements anytime	
1	Large movement anytime	

Goddard (1996) describes these five reflexes as follows:

(1) The Moro reflex is a series of rapid movements made in response to any sudden unexpected occurrence. The Moro response can also be triggered by stimulation of the labyrinth due to change in head position (vestibular response), noise (auditory response), sudden movement or change of light in the visual field, and pain, temperature change or being handled too roughly (tactile response). The Moro reflex also activates the 'fight or flight' body response of adrenaline and cortisol hormones released into the bloodstream, hyperventilation and increases in heart rate and blood pressure.

(2) The TLR is vestibular in origin; it provides a positive response to gravity and also affects muscle tone. If it is retained then the child will have difficulties in balance, coordinating movements, and in judging space, distance, depth, time and velocity.

(3) The Spinal Galant reflex is used in the birth process, but if it is retained it may cause fidgeting and make sitting difficult. It can lead to problems with walking and bed wetting, and can affect concentration and short-term memory.

(4) The retained presence of the ATNR prevents the child crawling on their stomach with a fluent cross pattern of arm and leg movements. Crawling and creeping are needed for development of oculomotor functioning, visual perception, hand/eye coordination, crossing the midline and fusion.

(5) The STNR is a short term reflex that is used by the baby between 6 and 9 months old to be able to push up on his hands before developing crawling movements. Its continued presence affects eye motor control, and readjusting binocular vision from one distance to another. The difficulties in eye movement control will adversely affect hand/eye coordination and ball skills, and can particularly affect sitting and eating skills at the table.

In Australia, in 1994, McConnell showed that clinical observations of the ATNR and ocular movements could be used to differentiate children with DCD from both children that had below average motor skills and children with age appropriate motor skills or better (McConnell, 1994). These results were reinforced by a UK study (Chu, 1996) that showed that clinical observations of ATNR and ocular movements, especially pursuits, were significantly deficient in children with specific developmental disorders (SDDs) compared to a matched control group of children without SDDs.

As a therapy for retained primitive reflexes Goddard (1996) recommends a reflex inhibition programme of physical stereotyped movements, practised each day, to give the brain a 'second chance' to register the reflex inhibitory movement patterns that should have been made at the appropriate stage of development.

SS was tested for five primitive reflexes: the Moro, TLR, Spinal Galant, ATNR and STNR as described by Goddard (1996), (Reuterhall and Rasmussen, personal communication). The Moro had been integrated but the TLR, Spinal Galant, ATNR and STNR were retained. SS followed a programme of exercises (Reuterhall and Rasmussen, personal communication) for 3 months to integrate and inhibit his retained primitive reflexes.

Once the retained reflexes had been inhibited SS was optometrically reassessed, and a programme of OVT planned. Plans for the OVT programme are individually developed from analysis of the visual assessment result. Each OVT exercise was devised using the principles outlined in Appendix 1.

The programme involved weekly 30 min sessions at the practice for 8 months, with home practice of 15 min per day between visits. Each sixth week was a reassessment visit to determine which areas needed further development. Appendix 2 shows a list of the OVT exercises used for practice and home therapy.

Optometric results

Table 2 shows the results of three assessments on SS.

(1) The AC/A ratios were variable on original assessment, but had steadied by the assessment on 15 August 2003, as the expected norms.

(2) Fusional reserves. SS's results show improvements in all fusional reserves to the top of the children's normal ranges (as Table 2). For base out at near, SS improved by 2 S.D. for break from 8 to 25Δ, and also by 2 S.D. for recovery from 6 to 20Δ. The adult expected values for base out at near are 19Δ for break, with S.D. $\pm 9\Delta$, and 14Δ for recovery, S.D. $\pm 6\Delta$ (BABO 2003). So SS had developed an adult level of fusional reserves.

(3) Amplitude of accommodation remained good at 10 cm for each eye, and binocularly. Accommodative facility improved from R 9 cpm, L 9 cpm, and binocularly 7.5 cpm, to R 24 cpm, L 23 cpm and binocularly 22 cpm. From the 8- to 12-year-old norms (Table 2) these results represent a change of 6 S.D. monocularly and 5.8 S.D. binocularly. The adult accommodative facility norms are 11 cpm monocularly and 8 cpm binocularly (S.D. ± 5 cpm for both). SS's results represent a change of 3 S.D. monocularly and binocularly using the adult norms.

(4) Reading test. On initial assessment, SS (aged 8 years and 3 months) was reading an age 6/7 paragraph from the Maclure reading tests. At the conclusion of OVT, SS (aged 9 years and 2 months) was reading the age 10+ paragraph on the Maclure reading test, a change in reading age of 4 years.

Table 2. Optometric results

SS DoB 9.6.1994	**Expected values (BABO, 2003)**	**Original 18.09.2002**	**Post-reflex 13.12.2002**	**Final 15.8.2003**
Cover test	Dist 1Δ exo S.D. ±2Δ Near 3Δ exo S.D. ±3Δ	Small exo at near with fast smooth recovery	No deviation seen	No deviation seen
Motility		Full		
Convergence				
Near point		To nose	To 10 cm	To nose
Effort needed		Effort ++	Good repeats, easy convergence	Good repeats
Phorias				
Distance	1Δ exo S.D. ±2Δ	2Δ exo orthoV	Ortho H	1Δ exo
Near	3Δ exo S.D. ±3Δ	4Δ exo orthoV	3Δ exo	6Δ exo
Fixation disparity				
Distance		H NFD V NFD		
Near		H NFD V NFD		
AC/A ratio	4Δ/1.00DS S.D. ±2Δ/DS			
+1.00 on		4 to 11Δexo = 7Δ/DS	3 to 6Δexo = 3Δ/DS	6 to 10Δexo = 4Δ/DS
+1.00 off		11 to 6Δexo = 5Δ/DS	6 to 2Δexo = 4Δ/DS	10 to 6Δexo = 4Δ/DS
−1.00 on		6 to 2Δexo = 4 Δ/DS	2 to 2Δexo = 0Δ/DS	6 to 4Δexo = 2Δ/DS
−1.00 off		2 to 4Δexo = 2 Δ/DS	2 to 2Δexo = 0Δ/DS	4 to 6Δexo = 2Δ/DS
Fusional reserves	Children 7–12 years	Blur/break/recovery	Blur/break/recovery	Blur/break/recovery
Distance				
Base in		–/6Δ/4Δ	–/6Δ/4Δ	–/12Δ/10Δ
Base out		–/4Δ/2Δ	–/15Δ/6Δ	–/20Δ/15Δ
Near				
Base in	Break 12Δ S.D. ±5Δ Recovery 7Δ S.D. ±4Δ	–/15Δ/12Δ	–/15Δ/8Δ	–/20Δ/15Δ
Base out	Break 23Δ S.D. ±8Δ Recovery 16Δ S.D. ±6Δ	–/8Δ/6Δ	–/20Δ/15Δ	–/25Δ/20Δ
Accommodation				
Amplitude (cm)				
Right		10	10	10
Left		10	7	10
Bin		10	7	10
Facility, ±2.00 cycles/min	Children 8–12 years			
Right	12 cpm S.D. ± 2.5 cpm	9 cpm	14 cpm	24 cpm
Left	12 cpm S.D. ± 2.5 cpm	9 cpm	15½ cpm	23 cpm
Bin	5 cpm S.D. ± 2.5 cpm	7½ cpm	15 cpm	22 cpm
SS DoB 9.6.94		Original 18.09.02	Post-reflex 13.12.02	Final 15.8.03
Reading (Maclure chart)		N5, age 6/7	N5, age 7/8	N5, age 10+
Physiological diplopia		Poor	Accurate	Accurate
Brock string		Not aware of where he is looking.	Beginning to make a cross in the string at each bead.	9 jumps there and back easily along the string.
Maples eye movements				
Pursuits				
Ability		5	5	5
Accuracy		1	3	5
Head movement		1	3	5
Body movement		1	3	5
Saccades				
Ability		5	5	5
Accuracy		1	2	5
Head movement		1	1	5
Body movement		1	2	5

Table 2. Continued

SS DoB 9.6.1994	Expected values (BABO, 2003)	Original 18.09.2002	Post-reflex 13.12.2002	Final 15.8.2003
DEM				
V seconds		52.1	52	40.7
H seconds		65.8	62	46.6
V percentile ranking		25th	25th	50th
H percentile ranking		25th	30th	60th
Ratio percentile		40th	50th	60th
Retained primitive reflexes (Scored 0–4 where 0 = no reflex present)				
Moro		0	0	
Tonic labyrinthine reflex		4	0	
Spinal Galant		1	0	
ATNR		4	1 just	
STNR		3	1	
Mother's comments			Improved coordination. Better on trampoline. Can walk down stairs every other foot. Better dressing. Can now become dizzy. Eye contact now. Better concentration and less distracted by noises.	Success ++ with bat and ball. Reading much better, but still needs work on handwriting.Up two classes in swimming lessons.Great improvements in confidence. Spelling age now 10 years and 4 months

(5) During OVT, SS developed an awareness of physiological diplopia, and improved his stability of fixation and convergence control on the Brock string.
(6) There was a marked improvement in oculomotor control following reflex inhibition exercises, but by the end of OVT SS was scoring at the highest level on all counts for Maples Eye Movement testing.
(7) SS improved his scores on the DEM test, starting at the 25th percentile for both horizontal and vertical number reading, and ending on the 50th percentile for vertical number calling and 60th percentile for horizontal number calling. At SS's age the standard deviation for the DEM test is 8 s for vertical number calling, and 12.5 s for horizontal number calling. The results show an improvement of 1 S.D. for vertical number calling, and nearly 2 S.D. for horizontal number calling.

On 15 August 2003 OVT was discontinued, but SS was reviewed at 3-month intervals to check and ensure that there was no regression. On 29 May 2004 the improvements were still present, and his reading was confident and developing expression. His DEM score had improved to the 70th percentile for vertical number calling, and 80th percentile for horizontal number calling.

Occupational therapy

SS was seen for an occupational therapy assessment on 21, 22 and 29 January 2002 when he received his diagnosis of a subtle form of dyspraxia. He was also tested on 28 March 2002 with the SIPT (Ayres, 1988), which was developed by Dr Jean Ayres in the 1980s in South California, and was standardised on 2000 children throughout the USA. The SIPT was repeated on 28 July 2003 when SS was finishing OVT.

The first two subtests, Space Visualisation and Figure Ground Perception, evaluate the ability to perceive and discriminate form and space, without involving motor coordination.

The next five tests, Manual Form Perception, Kinesthesia, Finger Identification, Graphethesia and Localisation of Tactile Stimuli, assess tactile, muscle and joint perception, and combined motor and visual perception.

Praxis skills are evaluated in six different ways: (1) on Verbal Command; (2) Design Copying and (3) Constructional Praxis, which require visual form and space perception in addition to practic abilities; (4) Postural Praxis and (5) Oral Praxis, which require the child to imitate unusual body and oral postures assumed by the therapist; and (6) Sequencing Praxis, which requires patting out a copied rhythm using the right and left hands, and head.

The final four subtests, Bilateral Motor Coordination, Standing and Walking Balance, Motor Accuracy and Post-rotary Nystagmus, require sensory integration (Ayres, 1988).

The first SIPT test results showed that SS did not have a clear profile of a child with BIS defect or with somatosensory dyspraxia. However, it appeared that SS's problems were caused by poor postural control, and weak bilateral integration and sequencing skills. He also had some visual motor difficulties and sensory modu-

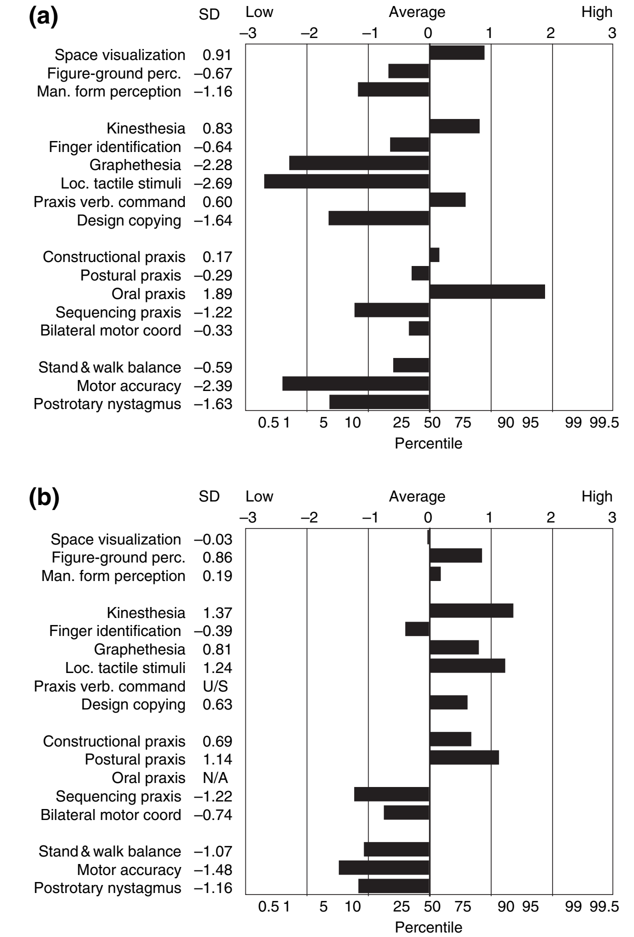

Figure 3. Sensory Integration and Praxis Test results. (a) Results on 28 March 2002 aged 7 years 9 months before OVT. (b) Results on 28 July 2003 aged 9 years 2 months after OVT.

lation problems. The SIPT results indicated that poor vestibular proprioceptive processing was the underlying cause.

The results of the two SIPTs can be seen in Figure 3. The results are based on normal distributions, and the graphs have standard deviation from the norm on the x axis and SIPT subtest on the y axis.

The largest changes in SIPT subtest results were in those tests combining motor and visual perception. Localisation of Tactile Stimuli showed an increase of 3.93 S.D., Graphesthesia showed a rise of 3.09 S.D., and moved from the 2nd percentile to the 80th. Design Copying showed an increase of 2.27 S.D., moving from the 5th percentile to the 70th.

For the visual system SS did not concentrate well for the first subtest, Space Visualisation, and so the result was not an accurate reflection of his abilities. However, he made significant gains in Figure Ground Perception and Manual Form Perception. Praxis on Verbal Command and Oral Praxis were not repeated as they had average or above average scores on the first SIPT. The vestibular based tests of sensory integration had not shown the same improved responses because the improved visual and tactile skills had not been generalised. In Sensory Integration Therapy, bilateral integration and sequencing skills are treated after deficits in the sensory systems.

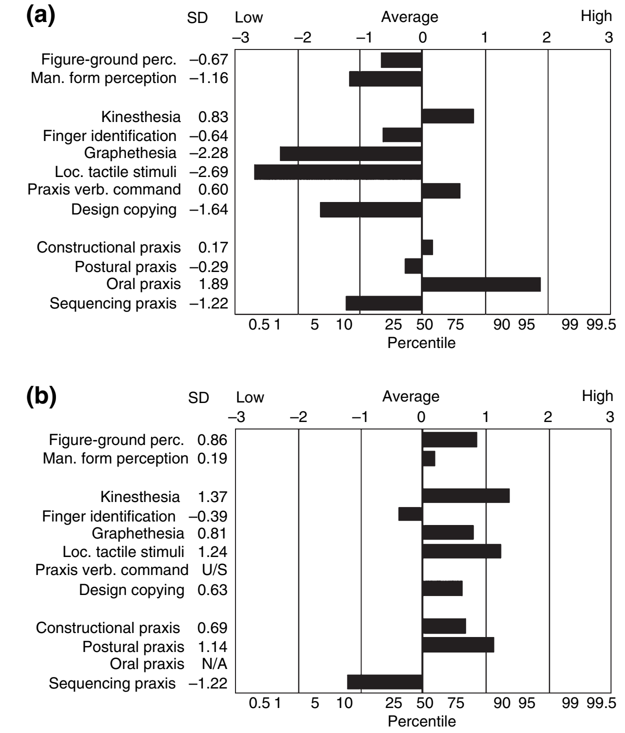

Figure 4. Sensory Integration and Praxis Test results relating to OVT. (a) Results on 28 March 2002 aged 7 years 9 months before OVT. (b) Results on 28 July 2003 aged 9 years 2 months after OVT.

Figure 4 shows the two SIPT results again, but without Space Visualisation, as that had an unreliable test result, and with the four sensory integration tests removed as the improved visual and tactile skills had not been generalised. Therefore, the remaining SIPT subtests show the improvements made due to OVT and natural development. Table 3 shows the standard deviation positions after both SIPT tests and the change in standard deviation position. The mean change in standard deviation position was 1.49 S.D.

Life skills

Other improvements in SS's motor skills were noted by his mother (personal communication), as well as improved reading, spelling, concentration and being less distracted at school. Physical coordination had improved especially in swimming, trampolining, riding a bike and bat and ball skills. SS was now able to go downstairs placing one foot in front of the other, could become dizzy, and could work a swing by himself. Socially, SS was now able to make eye contact, and had an increased confidence in talking to other people.

Table 3. The standard deviation positions after both SIPT tests, and the change in standard deviation position in those subtests relating to OVT

SIPT tests	S.D. on 28.3.02	S.D. on 28.7.03	Change in S.D.
Visual system tests			
Figure-ground Perception	–0.67	0.86	1.53
Manual Form Perception	–1.16	0.19	1.35
Combining motor and visual perception			
Kinesthesia	0.83	1.37	0.54
Finger Identification	–0.64	–0.39	0.25
Graphethesia	–2.28	0.81	3.09
Localisation of Tactile Stimuli	–2.69	1.24	3.93
Design Copying	–1.64	0.63	2.27
Praxis			
Constructional Praxis	0.17	0.69	0.52
Postural Praxis	–0.29	1.14	1.43
Sequencing Praxis	–1.22	–1.22	–
		Total change in S.D.	14.9
		Mean change in S.D.	1.49

Conclusions and discussion

This case study shows the changes that SS made in his visual, perception, motor, practic and life skills following a programme of reflex inhibition exercises and OVT for 11 months. The optometric testing showed significant improvements in fusional reserves, accommodative facility, oculomotor control of pursuit and saccadic eye movements, fixation and convergence control. For fusional reserves and accommodative facility SS showed the expected results of an adult.

SS's reading level had changed by 4 years in 11 months.

The SIPT results reinforced the optometric findings showing large improvements in the visual and motor/visual perception subtests. Although the SIPT vestibular based test did not show the same gains, the vestibular occupational therapy undergone before attending optometric practice may have primed SS's sensory systems for improvement. We expected that optometric intervention would have changed the visual performance status of this patient, but it was of considerable interest that the SIPT outcome measures and quality of life measures also indicated strong improvement.

There have been many treatment modalities suggested for treatment of dyspraxia (DCD). These include physiotherapy, Sensory Integration Occupational Therapy including Le Bon Depart, DDAT treatment, neurophysiology (primitive reflex), Davis method, sound and light therapy, fish oil supplement and audio therapy. However, there have been relatively few studies confirming the effectivity of these approaches in terms of the impact they have on the SIPT outcome measures (Kimball, 1990).

There is some evidence that physiotherapy interventions are useful in dyspraxia (DCD) especially in relation to motor skills (e.g. Lee and Smith, 1998, 2002) but we found no studies that related SIPT as an outcome measure. Neurophysiological treatments for retained primitive reflexes have been shown to be helpful (e.g. McPhillips *et al.*, 2000). However, evidence for some interventions remains very controversial. The DDAT treatment has been claimed to be effective in reading difficulties (Reynolds *et al.*, 2003), but their paper was heavily criticised (Singleton and Stuart, 2003).

We found only one study that showed improvement in sensory integration following Le Bon Depart (Leemrijse *et al.*, 2000), and there were no studies that showed the effectivity of OVT in relation to improvements in sensory integration outcome measures.

It is clear that further research is urgently needed and should include a larger group of children with dyspraxia (DCD), and optometric and SIPT testing of a control group to find the changes made due to natural child development.

There is a continuity of approach between these two complementary therapies: Sensory Integration OT and OVT. Sensory Integration OT is aimed at the underlying processing deficits, to facilitate the development of praxis, rather than specific behaviour or skill development (Cormack and Larkin, 2002). The sensory integration therapist builds motor patterns by using multiple contexts and changes in the surface characteristics of the task. In this way the child must change some part of the adaptive response, therefore building a motor repertoire (Cormack and Larkin, 2002). During OVT the child is given the opportunity to re-learn visual skills by rearranging conditions so that he/she becomes aware of new relationships in his/her visual world (Birnbaum, 1993).

This case has shown the close links that there are between OVT and sensory integration occupational therapy, and the benefits that can be gained by patients if there is inter-professional teamwork.

A recent literature study (Rawstron *et al.*, 2005) showed that small controlled trials and a large number of case studies support OVT eye exercises in the treatment of convergence insufficiency (e.g. Adler, 2002), but that as yet there is no clear scientific evidence published in mainstream literature supporting the use of eye exercises in the other areas reviewed, i.e. ocular motility, accommodative dysfunction, stereopsis, learning difficulties, amblyopia, myopia, motion sickness and sports performance.

It is clear that both the optometric and occupational therapy SIPT results from this case study support the use of OVT eye exercises in dyspraxic children who have ocular motility, accommodative dysfunction, learning difficulties and sports performance problems.

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Appendix 1. Principles for devising optometric vision therapy exercises (BABO, 2003)

(1) It should have value itself
(2) It should prepare for future procedures
(3) It should provide a means for both patient and optometrist evaluation
(4) It should sustain visual attention and contain a visual decision
(5) There should be positive stress
(6) It should relate to abilities needed in the real world
(7) Visual abilities should be rapid, sustained and at an automatic level

Appendix 2. Optometric vision therapy exercises for home therapy

Brock string	Press (1997, p. 213, 362)
Coin circles	BABO (2003)
Eye control	Adler (2002, p. 568)
Flippers	Birnbaum (1993, p. 338)
Hart chart	Birnbaum (1993, p. 332, 337)
Marsden ball	Birnbaum (1993, p. 320, 323)
Physiological diplopia	BABO (2003)
Pie pan rotations	Streff (2001, p. 94)
Pointer in the straw	Press (1997, p. 193)
Rotations	Birnbaum (1993, p. 320)
See three coins	BABO (2003)
Space matching	Press (1997, p. 198)
Thumb rotations	Streff (2001, p. 84)
Trombone reading	BABO (2003)
Word fixations	BABO (2003)

In practice these were supplemented by bimanual lines (BABO, 2003), motor equivalents (Press, 1997), and the use of a balance board (Press, 1997), rotator (Birnbaum, 1993) and illuminated vectograms (Birnbaum, 1993).