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Improved reading and academic performance: A case series of 3 dyslexic students with learning disability

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Narrative: This case series discusses 3 cases of students diagnosed with dyslexia and struggling with learning disability who received chiropractic care and functional neurology therapy based on the Melillo Method™

Hemispheric model theory suggests that the left cerebral hemisphere is associated with language development. It is therefore important to identify areas of inconsistency in the left cerebral hemisphere that may be associated with developmental delay. Therapeutic stimulations may yield hemispheric balance and enhance language development, equipping students to improve their academic performance. (17, 35)

The improvements of reading levels and academic performance in these 3 cases provided the practitioners, parents, educators and students themselves with direction to approach learning disability and dyslexia. The common presentations shared across these cases were inattention, poor memory, slow processing, poor comprehension, difficulty following instructions, inability to multitask, lack of motivation, delayed speech, spelling and reading difficulty, and poor handwriting.

Inspired by Melillo Method™ the main strategy was to follow bottom-up, the developmental trajectory that begins in the brain stem, followed by the vestibular system in the rhombencephalon, then the sensory and motor cortices and eventually the prefrontal cortex. (26) A comprehensive assessment was designed to examine the maturity of the central nervous system from the brain stem to the cortical level. This included a hemispheric checklist, vital signs, primitive reflexes, vestibular assessment, ocular motor assessment and neural timing assessment.

The treatment plan aimed to promote neuroplasticity by building networks in the targeted brain functional areas, the left hemisphere in these patients. The treatment modalities included Chiropractic Adjustments and 24 brain-based therapy sessions over 12 weeks using photobiomodulation, digital therapy, dynamic balance training, neural timing training, ocular motor training with co-activation of colour, auditory, olfactory and sensory-motor stimulation during the above-mentioned training protocols. The program was also reinforced by an individually designed home exercise program to integrate primitive reflexes and maintain the intensity and frequency of brain stimulation daily. In the 12-week period, the student subjects show improvement in their reading and academic performance as well as their work ethics, motivations and emotional stabilities. Objective functional measurements also displayed marked improvement across the board in most post-program physical and neurological assessments.

Indexing Terms: Chiropractic; Adjustment; Melillo Method; dyslexia; reading difficulties; NeuroImpulse Protocol.

Introduction

Dyslexia is a neurobiological learning disability, defined by word recognition difficulty and poor spelling abilities despite normal intelligence and adequate education and exposure to written material (38).

According to the Department of Education, dyslexia is the most common form of learning disability in Australia. The National Assessment Program, Literacy and Numeracy (NAPLAN) shows the national reading level with 10.3% of students who met the 'Needs additional support' level in 2024. (1) Extensive evidence shows that dyslexia commonly overlap with many other learning disabilities, including language impairment, ADHD, and developmental coordination disorder. (5)

... an integrative approach combining NeuroImpulse protocol Chiropractic Adjustments and Melillo Method™ functional neurology for clinical management of 3 school students with developmental dyslexia'

A review of theoretical research in dyslexia suggests that it may be due to auditory, visual sensory, or cerebellar deficits affecting the fluency of learning, along with a phonological deficit, a processing speed problem or a combination of issues. Traditionally students with dyslexia receive help from educators trained in diverse learning utilising a structured language approach. These may be limited to auditory, visual and verbal training that require substantial cognitive abilities from dyslexic individuals.

However, many of these dyslexic individuals started with neurodevelopmental delay including poor cognitive function. This makes the traditional approach less appealing and can compromise its effectiveness.

Assessments

Hemispheric checklist

The *Childhood Neurobehavioral Hemisphere Checklist* designed by Melillo is a questionnaire that helps to quantify overall neurodevelopmental delay. The checklist contains left and right brain characteristics in motor, sensory, emotional, behavioural, academic, immune and autonomic categories. This was completed by the main carers of the 3 student subjects. (26)

Chiropractic assessment

The Chiropractic assessment included joint motion palpation, deep tendon reflexes and myotomes to identify vertebral and extra-vertebral subluxations.

Vital signs

The brain stem contains autonomic nuclei and is responsible for vital functions such as heart rate, blood pressure and respiration. Vital signs, including pulse rates, blood pressure, respiration rate, spirometry and blood oxygen saturation, were assessed to investigate the brain stem maturity. These assessments were taken bilaterally to enable comparison for symmetry.

Primitive reflexes

Primitive reflexes are involuntary motor expressions that emerged before and shortly after birth to protect and assist the development of newborn babies during the first year of life. These reflexes are housed in the cranial nerve and autonomic nuclei in the brain stem. As the brain matures with higher cortical functions established, these reflexes should be integrated and disappear. Retained primitive reflexes compromise growth and development. Fear paralysis, Moro, Rooting, Palmer, Babinski, Spinal Galant, ATNR, STNR and TLR were the 9 primitive reflexes assessed. Each of these reflexes, when retained, were thought to be associated with specific neurodevelopmental dysfunctions and neurobehavioral symptoms. (25)

Vestibular and balance assessments

Postural equilibrium and balance are regulated by the cerebellum and vestibular system in the rhombencephalon. Rhomberg, Mann, single leg-stand and Fukuda stepping tests were assessed for both static and dynamic balance functions. Finger-to-nose, end-stage nystagmus and head-shaking nystagmus were assessed for vestibular-ocular functions.

Ocular motor assessment & The RightEye Sensorimotor System™

The ocular motor system controls the position and conjugate movements of the eyes and requires synergistic working from the frontal eye field in the frontal lobe, parietal lobe, cerebellum and ocular motor nuclei in the brain stem. The RightEye Sensorimotor System™ is a technology that records, views, and analyses indiscernible eye movements to identify and address visual tracking impairments. The RightEye system is employed to assess ocular motor functions with saccades, pursuit, convergence fixation, reaction times and eye movement metric during reading tasks. (37)

Optokinetic reflex (OPK)

The optokinetic nystagmus is an ocular reflexive response to follow moving objects with the eyes while the head remains stationary. The reflex is characterised with repeated pursuit moving object follow by saccades back to centre producing a continuous nystagmus response.

The OPK pathway involves cortical ocular motor projections from the parietal and frontal lobe to the extra-ocular muscles, and can thus be used to assess cortical ocular motor development. OPK-to-right is a right hemispheric function and OKP-to-left is a left hemispheric function.

Neurotiming with interactive metronome

Interactive Metronome objectifies and measures a subject's ability to synchronise motor movements with steady auditory beats. Assessment tasks involve clapping to metronome beats, aiming to clap on the beat. This involves neurotiming, attention, auditory processing, temporal processing, motor coordination, and executive functions. Brain regions involved include the auditory cortex cerebellum, prefrontal cortex (PFC), basal ganglia, and cingulate gyrus. The accuracy of the claps on the beats are measured in milliseconds. A lower task average in milliseconds indicates better neurotiming. (16)

Therapeutic intervention

Treatment aimed to promote neuroplasticity and build neural networks in the underdeveloped, underactive and under-regulated areas identified in the brain and provide specific stimulations with specific intensity and frequencies to improve strength and function.

To build neural networks, these 3 student subjects received a 24-session stimulative therapy program over 12 weeks. The therapy includes Chiropractic Adjustments, photobiomodulation with low-level class 3B laser, digital therapy, sensory stimulation (colour therapy, olfaction stimulation, vibration, auditory stimulation), ocular motor training and neurotiming training.

Apart from the main program, brain stimulation was further enhanced with an individually prescribed home program to be completed daily. The purpose of the home program was to ensure daily frequency of brain stimulations to yield neuroplasticity.

Chiropractic Adjustments

The role of Chiropractic treatment is to ensure minimal nerve interference by removing vertebral and extra-vertebral subluxations. The choice of Chiropractic assessment and technique with these cases was '*NeuroImpulse Protocol*™' (NIP™). The NIP™ is a brain-based Chiropractic technique developed by NJ Davies DC. The key concept of NIP™ is that any aberrant sensory input, such as pain and/or mechanical fault from joints and muscles, will result in dysafferentation to the central nervous system and, in turn, alter the motor output, resulting in subluxations.

NIP™ is characterised by its precision assessments to identify all subluxations, each with their own kinesiopathology (joint fixations associated with neuropathology), neuropathology (myotome, dermatome, deep tendon reflexes, sclerotome) and compensatory patterns (joint fixations without neuropathology). Gentle tonal impulse adjustments applied to identified subluxations normalise the kinesiopathology, neuropathology and compensatory patterns. (8)

Photobiomodulation

The neuronal effect of the light therapy in the form of laser will increase cellular mitochondrial membrane potential and increase electron transport to produce ATP. This improves cellular signalling by reactive oxygen species and triggers cellular changes that lead to beneficial cellular responses, including enhanced antioxidant defences and improved neuronal functioning. (13) Low-level laser with 637 nm red light and 809 nm near-infrared light was directed to the brain stem, right cerebellum, left sensory cortex, left motor cortex, left prefrontal cortex, left Broca's area and left Wernicke's area with specific frequencies tailored to these targeted brain regions. The red-light setting aimed to promote blood flow while near-infrared light, with its longer wavelength, penetrated the cranium to each targeted tissue depth.

Sensory co-activation

Sensory co-activation selectively stimulates multiple neural networks with sensory input in the targeted hemisphere to increase metabolic demand, thereby triggering an increased cerebral blood supply to that hemisphere and maximising the effect on those co-activated neural hubs. The sensory co-activations used were colour therapy for the visual cortex, aroma therapy for the olfactory cortex, music therapy for the auditory cortex and vibration therapy for the somato-sensory cortex. These co-activation strategies were applied both during in-clinic therapies and the home program.

Left hemispheric sensory co-activations were applied based on the clinical data obtained from the initial assessments, which indicated the left hemisphere being the underdeveloped hemisphere:

- Colour therapy to have the subjects wear red lens glasses.
- Aroma therapy with scented essential oils drops on left collar of the shirts.
- Auditory stimulation with beta frequency music played to right ear.
- Rezzimax turner, a hand-held vibration device strap to the right arm with vibration frequency over 40 Hz.

Digital therapy (Neurosage)

Neurosage™ is a video game designed by functional neurologists, which intentionally utilises video games as an advantage to get child patients to engage with therapy. Neurosage™ follows the hemispheric model and includes left-brain and right-brain games providing hemispheric visual (colour and graphic animations), auditory (sound source and frequencies), ocular motor (direction of eye movements), vestibular (hand-eye coordination), cognitive-motor (goal-directing) and neurochemical (dopamine and serotonin release) activations.

Game activities ranged and progressed from balance and coordination through to mood-behaviour and cognition. (7) For left hemispheric stimulation, the games exhibit more low-frequency colour and more detailed but higher speed animation and higher frequency sound source coming from the right-ear headset. While playing Neurosage™ video games, the student subjects had their right foot on a vibration plate vibrating from 10-40 Hz and their left foot stood on a bosu ball.

Ocular motor training

Each student received 10 minutes of left hemispheric eye movement training, which included slow pursuit from right to left and upward, fast saccade from left to right and downward, hemistim alternating red and yellow colour blocks at top left quadrant to target left parietal, left frontal eye field, brain stem and right cerebellum stimulation.

Neural timing training (Interactive metronome)

Students received interactive metronome training to perform sets of 3-minute tasks with both hands, both toes, right hand and right toes at tempo 54 bpm. The aim was to reach an average time below 40 ms. (16)

Home program

Students received an Individually designed home program of specific exercises to integrate retained primitive reflexes, strengthen core stability, improve static balance, cross lateral exercise to integrate left-right brain, left brain OPK stimulations and Vagus nerve stimulation.

All home protocols were to be performed with sensory co-activations including red glasses, scented essential oil drop on the left collar, and high frequency music to the right ear. The home program was to be performed at least twice daily.

Case 1 student

This was a 9-y-o female student diagnosed with dyslexia and dysgraphia by her developmental paediatrician. She also had grommets in both ears. She was born by emergency C-section followed by breathing difficulties and spent her first 2 days in the NICU. She was struggling with reading, writing and spelling. She also had poor concentration and short-term memory and struggled to retain information and follow instructions. Her school report card showed she failed English, maths and science but achieved a high standard in PE, music and technology. Teacher's comment: 'Only able to decode simple words really slowly. Unable to recognise more complex graphemes and phonemes. Gets distracted easily in class'.

The student subject appeared to be uninterested when asked questions and took long pauses before providing answers during the initial consultation.

Key clinical findings

- Hemispheric checklist: Right brain scored 6 and left brain scored 30. Suggesting overall left hemispheric delay.
- Asymmetry blood pressure reading: Right arm 106/73 mmHg, Left arm 115/81 mmHg. Pulse rate right side 91 bpm and left side 97 bpm, indicating dysregulation and imbalance in the cardiovascular centre in the brain stem.
- Elevated respiration rate at 28 bpm exhibiting high sympathetic tone.
- Depressed blood oxygen saturation right side 96%, right side 97%.
- Hyporeflexia of left upper and lower limb DTR indicating hypotonia.
- Retained primitive reflexes: Fear paralysis+2, TLR flexion and extension+1, Moro+1, Left ATNR+1, bilateral rooting+1, right palmer+1, left palmer+2, STNR flexion+1. Total 7 primitive reflexes retained suggesting an underdeveloped brain stem.
- Headshaking nystagmus with fast phase observed at right, indicating left VOR dysfunction.
- Rightward OPK sustained 11 beats nystagmus, downward sustained 3 beats, leftward sustained 4 beats nystagmus and downward sustained 3 beats nystagmus. This suggests poor cortical ocular motor strength bilaterally but weaker on the left frontal eye field in the motor cortex.
- Mann's test (tandem stand) swayed to the right indicating right cerebellum weakness.

- Significantly reduced sensitivity of left nostril smell. This may suggest left olfactory cortex dysfunction.
- The RightEye Sensorimotor System™ revealed poor convergence fixation, poor horizontal slow pursuit, poor anti-clockwise slow pursuit, and poor vertical upward and downward slow pursuit.
- The RightEye Sensorimotor System™ reading assessment showed eye movement when reading left to right metrics appeared to be jerky, inconsistent, repeating words or moving to wrong lines at times. Return sweep when moving to the next lines consistently undershot and missed the beginning of sentences. Insufficient fixation duration at words read may compromise reading comprehension or attempts at repeating words read. Extended blinking may lead to eye strain or fatigue, affecting concentration when reading. (Figure 1)
- Interactive metronome tasks display 329 ms task average when performing 1-minute clapping task indicating poor neurotiming; and assessment without the guide sounds at 351 ms task average. This showed difficulty in processing multi-sensory input when performing tasks with added prompts.

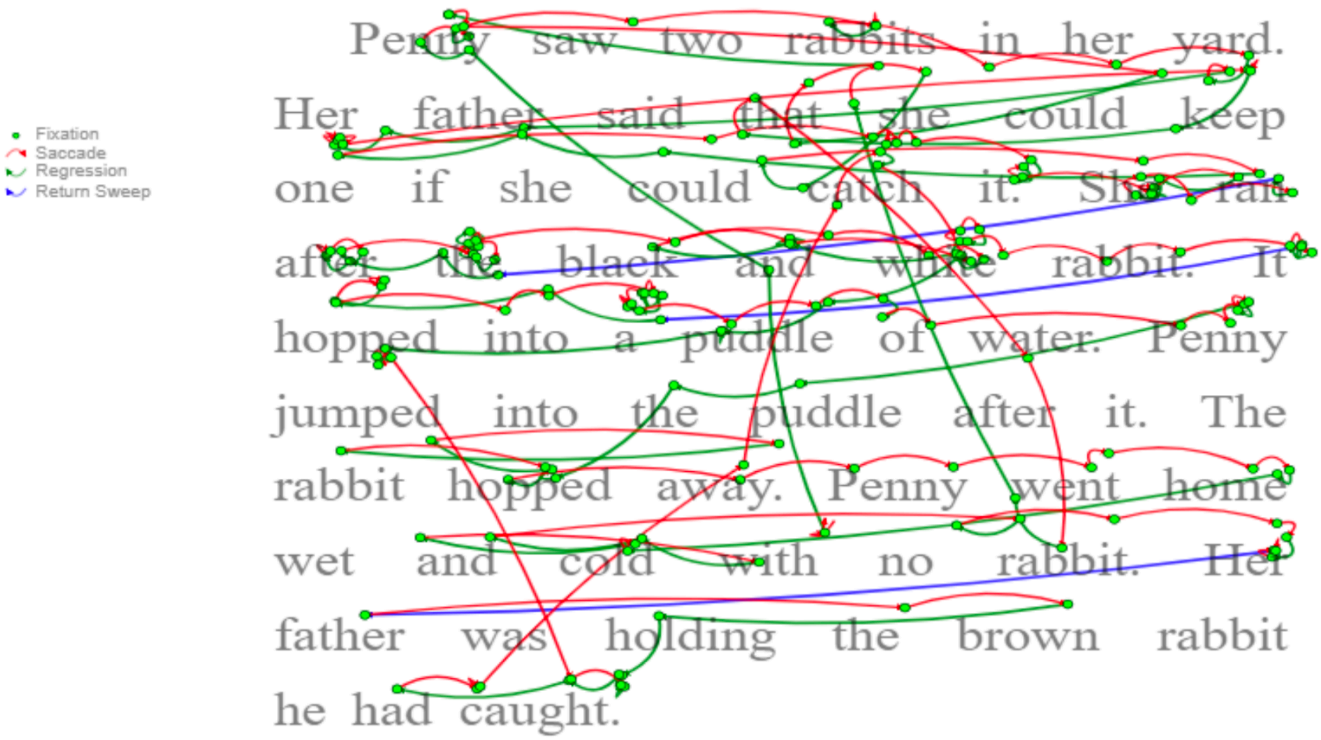


Figure 1: Case 1 Pre-therapy reading ocular motor assessment

Clinical impression

1. Brain stem immaturity with retained primitive reflexes, dysregulated blood pressure and elevated respiration rate, hypotonia, poor convergence fixation.
2. Left hemispheric weakness with hemispheric checklist indicators, hyporeflexia of right upper and lower limbs, right Babinski reflex, left ATNR, weaker leftward and downward OPK, Poor anti-clockwise slow pursuit and right saccade; reduced sensitivity of left nostril smell.

3. Right cerebellum and vestibular weakness with right hyporeflexia DTR and tendency of falling right with single-leg stands.
4. Poor neurotiming and synchronisation with dysfunctions in motor control and sensory processing in neural networks involving motor, parietal, prefrontal cortex, thalamus, basal ganglia and cerebellum.

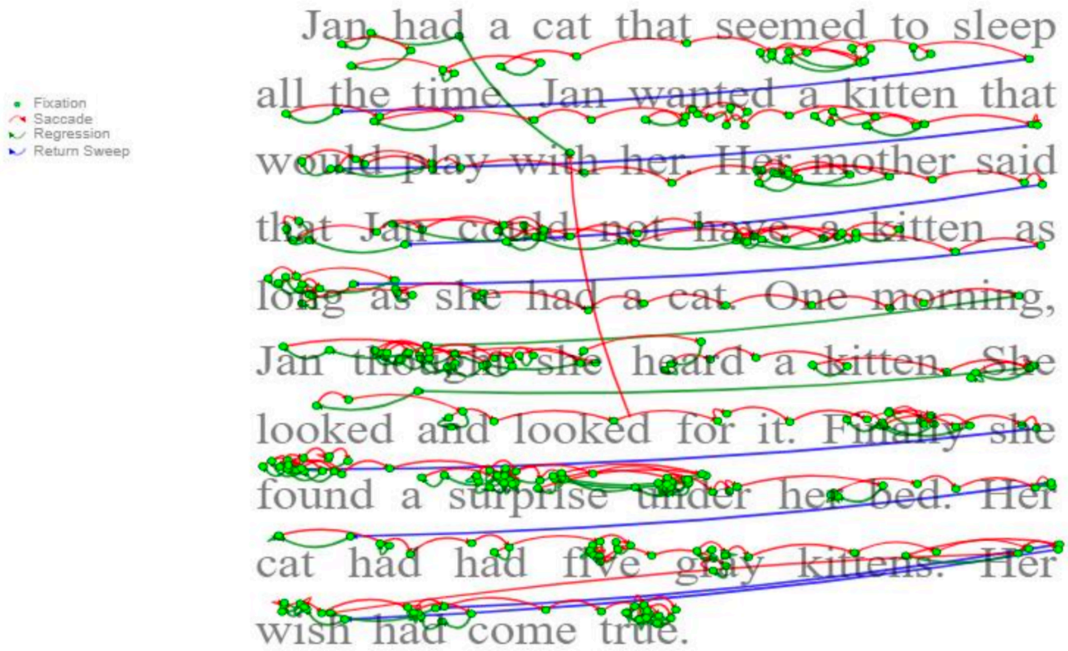
Post-therapy clinical outcome

Case 1 student responded to therapy. From the first week of the program, she appeared to be more emotionally regulated, better ability to retain information, and more able to concentrate and follow instructions. As she progressed through the program, her caregiver reported she became more talkative, more willing to accept challenges, was enjoying homework more and was generally happier. Her teacher reported her reading and handwriting improved while her academic report showed improvement in math and science.

Reassessment results showed:

- Symmetrical blood pressure with right side 104/58 mmHg and left side 105/56 mmHg.
- Pulse rate settled to right side 88 bpm and left side 82 bpm.
- Respiration rate settled to 18 bpm.
- Right biceps reflex normalised to +2.
- TLR flexion, TLR extension, right ATNR, rooting, Babinski, left spinal Galant integrated. Right palmer, STNR flexion, right spinal Galant improved by 1 grade.
- No headshaking nystagmus observed.
- Rightward OPK nystagmus improved to 9 beats, downward to 4 beats, leftward to 10 beats and upward to 6 beats.
- Left and right single-leg stands improved to 20 seconds.
- Interactive metronome task average without guide sound improved to 79 ms and 31ms with guide sound.
- The RightEye Sensorimotor System™ revealed poor convergence fixation, poor horizontal slow pursuit, poor anti-clockwise slow pursuit, and poor vertical downward fast saccade.
- The RightEye Sensorimotor System™ reading assessment showed more consistent and smoother left-to-right reading metrics and improved returning sweep to the beginning of the next sentence. Normalised extended blink and better fixation duration. (Figure 2)

Figure 2: Case 1 Post-therapy reading ocular motor assessment



Case 2 student

This was a 7-y-o female student diagnosed with dyslexia by her psychiatrist. She was diabetic and only began to walk at 16 months old. She was struggling with maths and English at school but achieving good grades in drama, music and technology. Her parent reported she had poor long-term and short-term memory and was unable to retell a story. She was unable to multitask and often struggled to comprehend instructions.

Key clinical findings

- Hemispheric checklist: Right brain scored 23 and left brain scored 53. Suggesting overall left hemispheric delay.
- Asymmetry blood pressure reading: Right arm 112/60 mmHg, Left arm 108/72 mmHg. Pulse rate right side 62 bpm and left side 108 bpm, indicating dysregulation and imbalance in the cardiovascular centre in the brain stem. (Note: consistent results with repeated measurements).
- Elevated respiration rate at 24 bpm exhibits high sympathetic tone.
- Hyporeflexia of right upper and lower limb DTR indicating hypotonia.
- Retained primitive reflexes: TLR flexion and extension+1, Left ATNR+2, right rooting+1, right palmer+2, left palmer+1, right Babinski+2, STNR flexion+2, bilateral Spinal Galant+2. Total 7 primitive reflexes retained suggesting an underdeveloped brain stem.
- Headshaking nystagmus with fast phase observed at right, indicating left VOR dysfunction.
- Rightward OPK sustained 5 beats nystagmus, downward sustained 2 beats, leftward sustained 1 beat nystagmus and downward sustained 2 beats nystagmus. This suggests poor cortical ocular motor strength bilaterally but weaker on the left hemisphere.
- The right and left single leg stand fell towards right after 5 seconds. This indicates weak left motor output with weak right cerebellum coordination.
- The RightEye Sensorimotor System™ showed poor convergence fixation, horizontal slow pursuit, anti-clockwise slow pursuit, and vertical downward fast saccade.
- The RightEye Sensorimotor System™ reading assessment showed difficulty in initiating eye movement with over fixation and took a long time to move from one word to the next and only managed to read 5 lines over a period of 2 minutes. Eye movement appeared to be jerky within the same word showing repeating between letters. Extended blinking may lead to eye strain of fatigue and affect concentration when reading. (Figure 3)
- Interactive metronome tasks display 96 ms task average when performing 1-minute assessment without the guide sounds and 99 ms task average with guide sounds, indicating poor neurotiming.

Clinical impression

1. Brain stem immaturity with retained primitive reflexes; dysregulated asymmetrical pulse rate and blood pressure; and elevated respiration rate, poor convergence fixation.
2. Left hemispheric weakness with hemispheric checklist indicators, weaker leftward and downward OPK, Poor anti-clockwise slow pursuit, left slow pursuit, reduced left nostril olfactory sensitivity.
3. Bilateral cerebellum and vestibular weakness.
4. Poor neurotiming and synchronisation with dysfunctions in motor control and sensory processing in neural networks involving motor, parietal, prefrontal cortex, thalamus, basal ganglia and cerebellum.

5. Slow motor activation especially with initiating eye movement when reading.

Post-therapy clinical outcome

Case 2 student experienced night terrors and woke up crying during the first 2 weeks of the therapy program. From the third week, she started showing improvements in reading especially in fluency when reading out loud and less frequently skipping words in sentences. From the 9th week, her parent reported noticeable improvement in memory and comprehension. The teacher reported her reading improved 5 levels within 1 term.

Reassessment results showed:

- Symmetrical pulse rate right side 97 bpm and left side 98 bpm.
- Respiration rate settled from 28 to 22 bpm
- Blood oxygen level became symmetrical and improved from 96% to 98% bilaterally.
- TLR, Moro, left rooting, Palmer, STNR, Left ATNR integrated.
- Downward OPK nystagmus improved to 8 beats, leftward to 6 beats
- Left and right single-leg stands improved to 10 seconds
- The RightEye Sensorimotor System™ showed centralised convergence fixation improvement.
- The RightEye Sensorimotor System™ reading assessment showed increased speed in initiation ocular movement and managed to complete the reading task in time. Normalised extended blink. (Figure 4)

Figure 3: Case 2 Pre-therapy reading ocular motor assessment

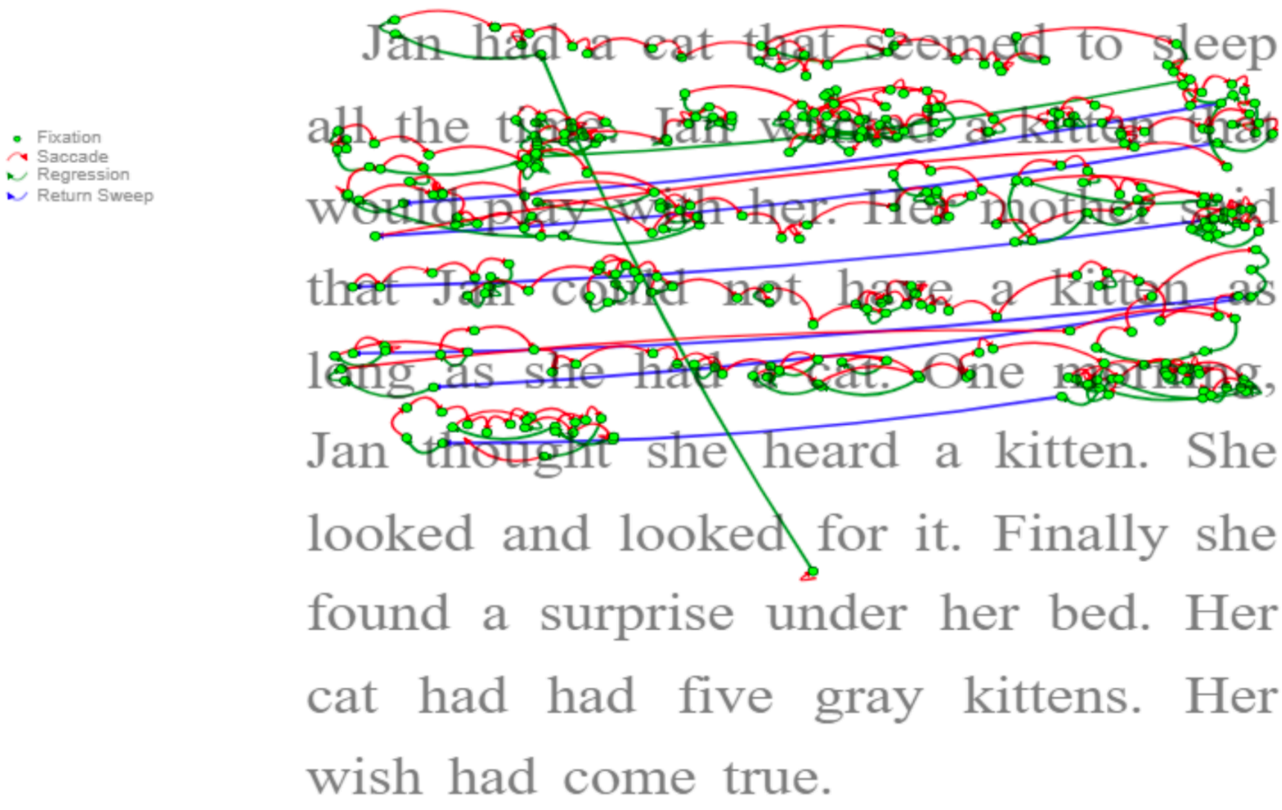
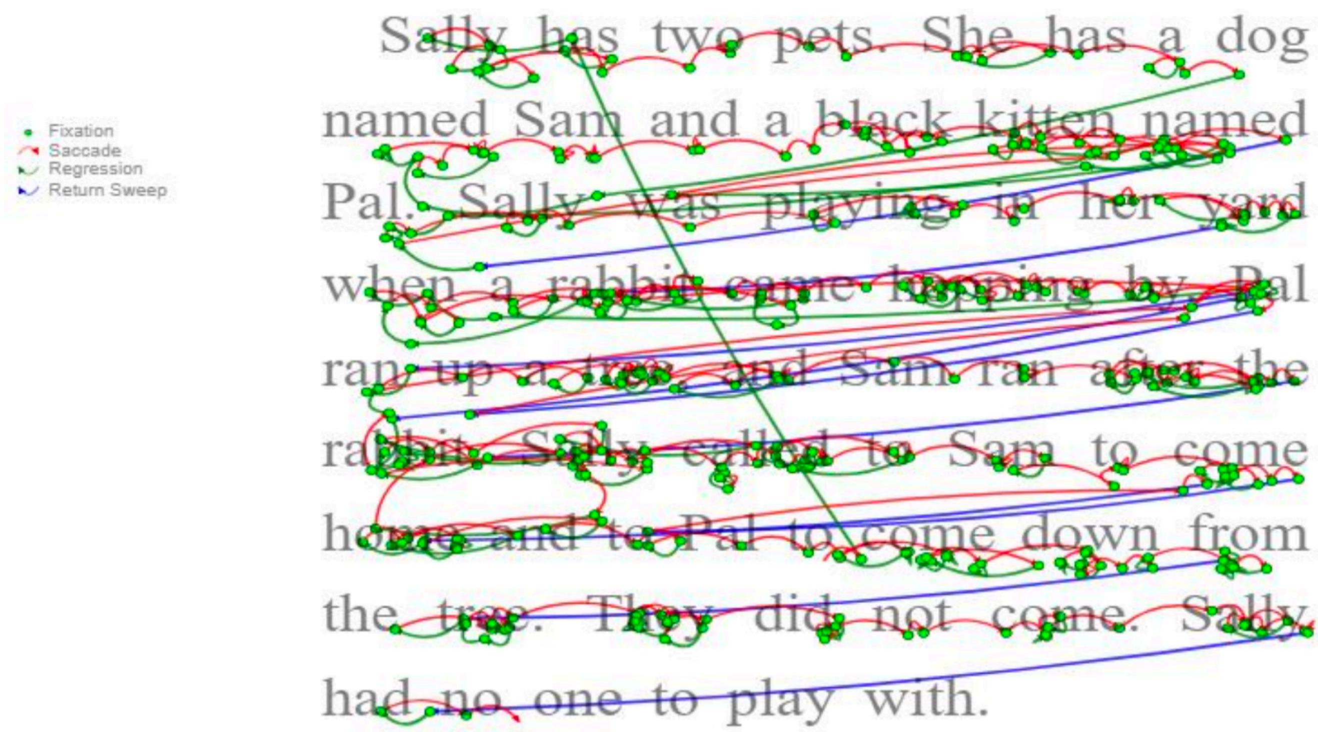


Figure 4: Case 2 Post-therapy reading ocular motor assessment



Case 3 student

A 15-y-o male student with no formal diagnosis but who was struggling with academic performance. He had difficulty retaining information, lacked motivation, had a poor work ethic relating to learning, and below average grades across all subjects. He was farsighted and also displayed poor hand grip strength. Born 8 weeks premature, he suffered from eczema and many allergies throughout childhood. Unable to express emotion easily, he experienced frequent meltdowns or became physical fights with classmates at school. He had previously been enrolled in a speech pathology program.

Key clinical findings

- Hemispheric checklist: Right brain scored 9 and left brain scored 19, suggesting overall left hemispheric delay.
- Retained primitive reflexes: TLR flexion+1 and extension+2, Left ATNR+1 and Right ATNR+2, bilateral rooting+2, Bilateral palmer+2, bilateral Spinal Galant+2. Total 5 primitive reflexes retained suggesting an underdeveloped brain stem.
- Right index finger undershot target and left index finger overshot target when performing finger-to-nose indicating right cerebellum dysfunction.
- Rightward OPK sustained 3 beats nystagmus, downward sustained 3 beats, upward sustained 5 beats nystagmus, suggesting poor cortical ocular motor strength bilaterally.
- The left single leg stand fell towards right, indicating weak left motor output with weak right cerebellum coordination.
- The RightEye Sensorimotor System™ showed poor convergence fixation, horizontal and vertical slow pursuit, anti-clockwise slow pursuit, and vertical and horizontal fast saccade.
- The RightEye Sensorimotor System™ reading assessment showed lack of normal left-to-right pursuit and right-to-saccade to next-line metric. Instead, eye movement jumped multiple

lines multiple times and slow pursuit left to right or moving back and forth between 2 or 3 words. Not a single line was read from far left to far right in full. (Figure 5)

Clinical impression

1. Brain stem immaturity with retained primitive reflexes and poor convergence fixation.
2. Left hemispheric weakness with hemispheric checklist indicators, Weaker upward OPK, Poor anti-clockwise slow pursuit, left slow pursuit.
3. Right cerebellum and vestibular weakness.
4. Poor ocular motor control.

Post-therapy clinical outcome

Case 3 student reported his concentration improved after the first therapy session. He then demonstrated consistent improvement after each session in reading comprehension, calmness, ability to express emotion verbally, less rigid thinking and more motivation in learning. His relationship with his older brother also improved. His school report showed he advanced 6 reading levels within 10 weeks and his grades improved 30% in all subjects in one semester.

Reassessment results showed:

- TLR, Palmer and spinal Galant integrated.
- The RightEye Sensorimotor System™ reassessment showed centralised convergence fixation and improvement in vertical and horizontal saccades, anti-clockwise, vertical and horizontal pursuit.
- The RightEye Sensorimotor System™ reading reassessment showed proper left-to-right slow pursuit and fast saccades to the next line consistently throughout the reading task. (Figure 6)

Figure 5: Case 3 Pre-therapy reading ocular motor assessment

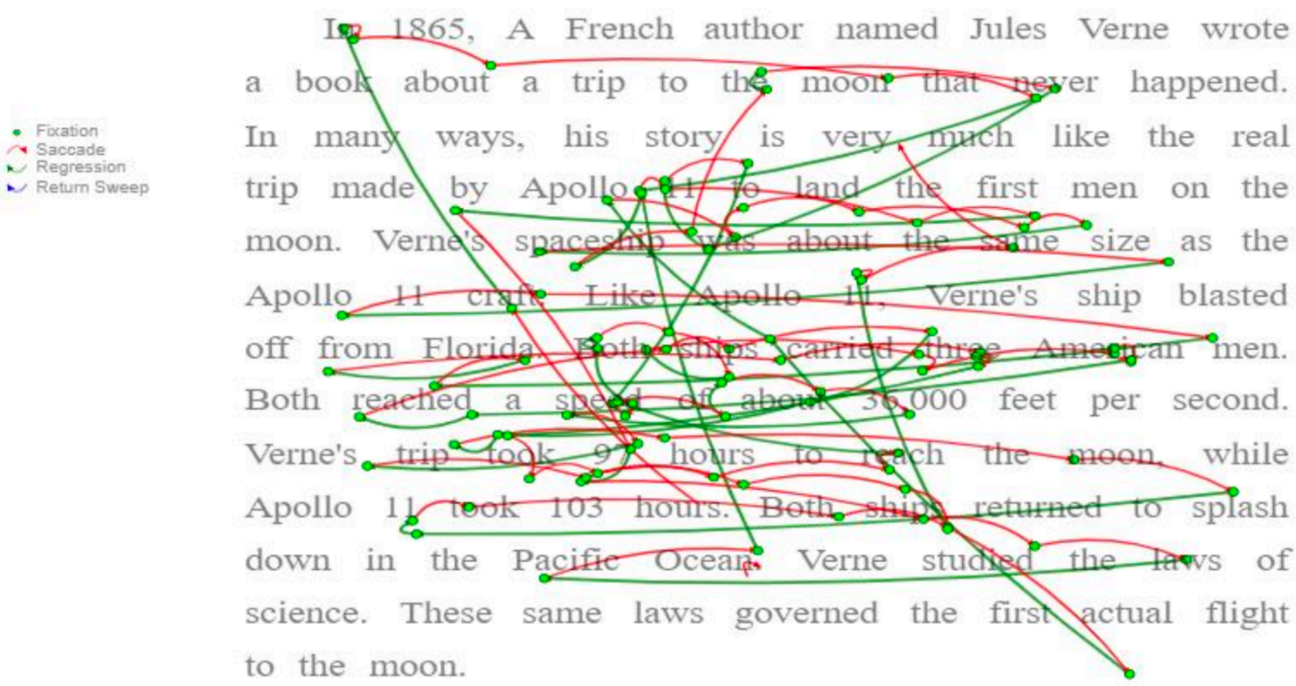
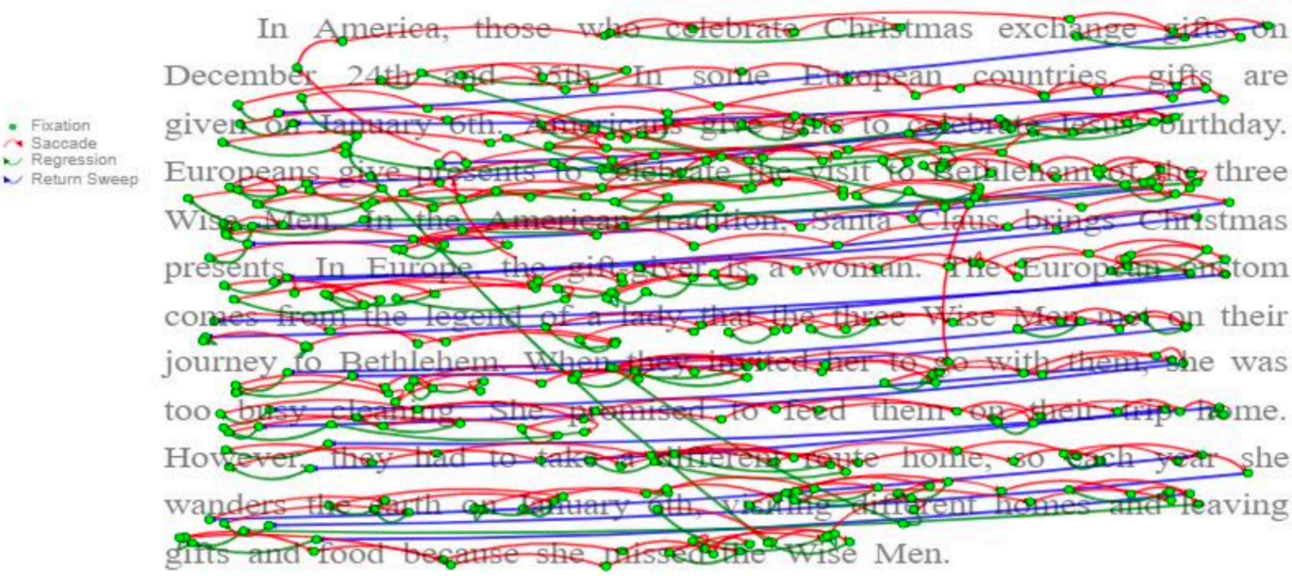


Figure 6: Case 3 Post-therapy reading ocular motor assessment



Discussion

Case 1 and 2 student subjects were both diagnosed with specific learning disability with impairment in reading (Dyslexia) under DSM-5 criteria. Case 3 student was not formally diagnosed, but was identified by his school as struggling in academic performance.

Cases 1 and 3 received therapy from a speech pathologist and cases 2 and 3 got help from both school educators and private tutors. All 3 cases reported little improvement in reading and no significant change in their school grades. This led their parents to seek therapy from the neurological based Melillo Method™ program offered by this clinic.

The common clinical presentation within all 3 cases is brain stem immaturity, left hemispheric weakness, right cerebellar weakness, insufficient ocular motor function and poor neurotiming associated with slow processing. Brain stem immaturity is evident by vital signs not meeting age-appropriate norms and many primitive reflexes still retained.

Elevated respiration rate and pulse rate representing these subjects exhibit a higher sympathetic tone commonly seen in normal newborns and toddlers. The presence of primitive reflexes is for protecting the developing newborn and assisting and preparing for next developmental stages while the brain is fairly immature. Once more advanced functions are developed at the cortical level, this will then inhibit and integrate these primitive reflexes at age-appropriate time, mostly before the first 12 months. Studies are finding the relationship between retained primitive reflexes and motor coordination in reading.

Primitive reflexes

Primitive reflexes are involuntary motor expressions that are housed within autonomic and cranial nuclei in the brain stem, that protect the newborn and facilitate development. Retained primitive reflexes indicate cortico-subcortical neuronal network impairment or possibly neuronal developmental delay. ATNR, STNR, TLR and Spinal Galant were found to be retained in our 3 dyslexic cases. These reflexes are linked to oculomotor functions together with muscle contractions when elicited. They played important roles in language development and reading mechanisms.

Typically, ATNR, STNR and TLR are involved in altering the tonus of limbs and trunk while altering the head position. Goddard Blythe stated '*If these reflexes elicited as a result of head flexion, extension, or rotation are uninhibited or if the postural reflexes depending on these primitive reflexes do not fully mature, the functioning of the cerebellum will be affected'*. (15)

The ATNR is associated with early visual-motor coordination, convergence fixation that leads to visual tracking and midline crossing skills. In the context of reading eyes are to cross midline when return sweep via fast saccade from far right to far left of next line on a text. Retained ATNR may disrupt midline crossing eye movements. ATNR also involved with contralateral extensor tonus and ipsilateral flexor tonus that may interfere with coordination of flexors in pencil grip when head to turn toward the writing hand and strengthen the palmar grasp reflex, in severe cases expressed as dysgraphia and disrupt written language development. (25)

Retained STNR affects the body's attitude to maintain a still upright posture. A linear head movement either flexion or extension will facilitate change of flexor and extensor muscle tone of the trunk or vice versa affecting the proper holding of the head in relation to the trunk position. This influences not only the balance of the trunk but also the control of eye movements which arise with convergence and spatial coordination problems in a tunnel-vision fashion which often cause eye strain during reading tasks. (4)

TLR assists with head-righting via activation of otolith apparatus specifically with head flexion and extension, which plays a crucial part for spatial orientation, balance and static posture via maintaining flexors and extensor tone. With retained TLR in the extension component, the effect of head extension leads to simultaneously having the tongue depressed and protruded and compromise fine motor control of muscles required for speech. TLR also contributes to the vertical conjugate eye movements as part of the vestibular-ocular reflex system. (22)

Retained Spinal Galant reflex results in tactile hypersensitivity, in severe cases even clothing may provoke involuntary contraction of back musculature leading to inattention, restlessness and hyperactivity that disturb learning. According to Goddard Blythe the Spinal Galant reflex is also a primitive conductor of sound. During uterine life, sound vibrations stimulate the skin, and the Galant reflex helps transmit vibration from the skin to the ear through a combination of skin and bone conduction (22).

Goddard Blythe conducted a study involving children with speech and language impairments and found that after auditory training, the strength of the Spinal Galant reflex had weakened. Such connections with auditory processing also point to a relationship between the Galant reflex and speech and language development in children.

Left hemisphere and right cerebellum insufficiency

All 3 student subjects have been identified as left hemisphere delay indicated by the results of hemispheric checklist, dominance profile, olfactory sensitivity and ocular motor insufficiency. It has been widely accepted that the left hemisphere is responsible for phonological awareness, auditory processing, and language development and with successful reading requires integration of different neural systems, such as the attention, articulatory, phonological, and semantic networks.

Research has identified a complex neural reading network, consisting of a predominantly left hemisphere. (36) A meta-analyses neuroimaging study utilising functional magnetic resonance imaging (fMRI) had converged on differences in brain activity in left lateralised cortical regions, mainly inferior frontal, temporal– parietal, and occipital-temporal cortices considered to be involved in phonological processing aspects of reading. (35) This is supported by the study by Shaywitz in 2002 where the dyslexic individuals compared with the normal reader, there is a decreased activity in the posterior left hemisphere and a lack of synchrony between the posterior and anterior areas in the left hemisphere and increased activity in the homologous areas of the right hemisphere especially the right frontal cortex (38) (41)

Subsequently Kronbichler confirmed with fMRI that there were connectivity impairments between the occipital-temporal and frontal areas might be indicative of a disrupted linkage between orthographic and phonological word representations what in turn leads to inefficient and slow reading performance as the occipital-temporal cortex in the left hemisphere is of the key areas related to rapid object naming when it comes to reading related skills such as word recognition, decoding and spelling, which explains the broad literacy impairments of dyslexia. (19)

Like all motor activities the synchronisation of the responsible motor cortex required with the opposite cerebellum modulation; in the context of reading being the left motor cortex to pair with the right cerebellum thus one should also consider right cerebellum insufficiency in the play of dyslexia. Roderick stated: brain activation was significantly lower ($p<0.01$) for the dyslexic adults than for the controls in the right cerebellar cortex and the left cingulate gyrus when executing the pre-learned sequence, and in the right cerebellar cortex when learning the new sequence. (28)

Recently, extensive studies have also observed cerebellar activation during reading, especially in the right cerebellar hemisphere particularly, lobules VI and VII in the early stages of reading acquisition. (21). This is evidenced in all 3 students subject presenting with poor ocular motor control in vestibular and cerebellum system.

Our treatment intervention specifically targets the left cerebral hemisphere and right cerebellum using photobiomodulation with co-activation via visual stimulation with low frequency colours, auditory stimulation with beta frequency music, olfactory stimulation with scent to left nostril, sensory-motor stimulation with vibration to right upper and lower limbs, and optokinetic reflex stimulation via upward and left ward eye movement and voluntary ocular motor eye training all the same time during therapy to maximise the effective to promote neuroplasticity in the left cerebral and right cerebellar hemispheres.

Role of dopamine

Dopamine is critical to motor functions in activation of movements, motivation, situational awareness and attention especially related to school learning. Low levels of dopamine lead to lethargic motor responses and slowed reactions. The reduction of dopamine release within the mesolimbic system appears to be a key precursor to the symptomatic reactions of loss of awareness and attention therefore a primary cause of inattention symptoms and slow processing speed in eye movements.

It is known that there are dopaminergic neurons highly dense around the cone cells within the retina. Activation of these dopaminergic neurons will enhance cone function and suppress the actions of the rod cells; this will result in increased colour sensitivity of eyes and visual cortex. This sensitivity then creates an excitation loop encouraging the increased release of dopamine via the ventral tegmental area. (7) Application of Neurosage™ is to use screen time as an advantage that makes therapy more engaging for the school student subjects. Based on Systemic Neural Adaptation (SNA), the games were designed with a hemispheric approach with considered eye movement in the games combined with specific frequencies of sound and light to stimulate either the right or left hemisphere. It aims to promote release of dopamine that will improve the activation of ocular motor function during reading, alertness and attention and motivation in learning activities.

Effect of Chiropractic Adjustments

NIP™ is used to identify and also correct vertebral and extra vertebral subluxations. The NIP™ Chiropractic adjustments help to eliminate kinesiopathology and neuropathology; this will promote healthier proprioceptive input, muscle stretch receptive input, reduced nerve irritation and dural tension that in turn allow proper motor expression. Typical observation that student subjects that received cranial subluxation corrections have an immediate improvement on the accuracy of performing finger-to-nose tests. This represents normalisation of motor coordination of the cerebellar dysfunction. The NIP™ cranial adjusting is guiding and assisted cranial plate motion as well as inducing cerebrospinal fluid movement from 3rd and 4th ventricle draining out caudally and thus reduced the tension in the diencephalon and rhombencephalon region. (8)

Conclusion

This case series presented an integrative approach combining NeuroImpulse protocol Chiropractic Adjustments and Melillo Method™ functional neurology for clinical management of 3 school students with developmental dyslexia.

A 12-week treatment program yielded significant improvement in reading levels, learning behaviour as well as academic grades across all subjects.

Objective finding including stabilisation of vital signs, reducing strength of primitive reflexes, and improved ocular motor functions. Further investigations and research are required to support this case study report and assist more school children with reading challenges and learning disabilities.

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Limitation

Our small sample size is a limitation of this study, we have 2 students with formal diagnosis of dyslexia and one without a formal diagnosis. Further studies need to be performed prospectively with larger numbers of confirmed dyslexic diagnosis for validating the effectiveness of this therapeutic approach. The grading of primitive reflexes may also have a probability of inter-practitioner reliability consideration in its measurements.

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