Behavioural Interventions to Remediate Learning Disorders: A Technical Report

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I INTRODUCTION

Learning disorders such as dyslexia, dyscalculia and attention deficit hyperactivity disorder (ADHD) can present significant challenges for children, parents, and educators. Combined, these disorders impair learning in as many as one in five children, with sometimes devastating repercussions for numerous aspects of their lives. Much knowledge has been gained recently by studying the neural correlates of such learning disorders, leading to the identification of specific neural networks that are altered in impaired learning (although questions remain regarding the causal links between these changes in neural activity and changes in behaviour).

Quite logically, advances in the scientific understanding of these disorders have paved the way for cognitive remediation programmes aiming to alleviate behavioural symptoms by targeting their underlying mechanisms. Although we believe this endeavour should be praised, marketed programmes often lack sufficient scientific evidence to back up their claims. This is prejudicial to individuals and institutions investing time and money into interventions that may not lead to the intended results.

In this report, we assess with a critical eye a selection of current popular remediation programmes. For each intervention we discuss, we provide an overview of the training tools and report on the strength of the evidence available at this time. Note that we do not have any financial involvement with these programmes, which means that there is no conflict of interest surrounding the statements reported here.

Finally, we want to emphasise that none of the sections in this report are definitive. Science is a collaborative enterprise, moving forward collectively, and we make no specific predictions regarding the future of each programme. Rather, as we mentioned, we have assessed and synthesised the evidence currently available to us in order to help parents, educators and policy-makers reach better, more informed conclusions.

II AUDITED PROGRAMMES

A Arrowsmith Programme

Website / for more information see:

http://www.arrowsmithschool.org/arrowsmithprogram/index.html

What it involves:

Arrowsmith offers a three to four year for-profit programme which replaces regular school tuition. It was developed by Barbara Arrowsmith-Young, author of *The Woman Who Changed Her Brain*. Its goal is to address the root causes of learning disabilities rather than managing their symptoms. Ostensibly the programme and its exercises are based on research in neuroscience, particularly on the principle of neuroplasticity and localisation of functions as described by A.R. Luria.

The Arrowsmith programme is delivered in a school setting by specially trained teachers. Arrowsmith mandates a teacher:student ratio of one Arrowsmith teacher to approximately 10 students. The overall class size can, however, exceed 10 students, so long as the appropriate teacher:student ratio is maintained.

Arrowsmith education begins with an individual online assessment process which takes approximately one day. Each student's results are submitted to Arrowsmith, which creates an 'Individual Learning Profile' for the student, identifying their strengths and weaknesses. Once a student's Individual Learning Profile has been created, he or she then spends approximately four periods per day, five days a week performing Arrowsmith cognitive exercises. These include computer, auditory and pen and paper exercises. The rest of the school day is usually devoted to more traditional English and mathematics teaching. The extent to which more traditional teaching is involved depends on curriculum regulations and individual students' needs. Each student's progress is tracked monthly on a web-based system, and a full year-end reassessment is carried out to update the student's Individual Learning Profile.

What claims does the company make / what does the programme target?

Relatively bold claims are made in support of the Arrowsmith programme. In its programme brochure it is stated that "[u]pon completion, and with the attendant improved cognitive capacities, students are able to participate in a full academic curriculum at their appropriate grade level without the need for resource support or curriculum modification" (Arrowsmith, 2010, p. 5)

Arrowsmith is not free and so details about its remediation processes are not available to the public. However, based on Arrowsmith-Young's (2013) book *The Woman Who Changed Her Brain*, the programme seems to identify and target the following deficits:

(1) *Motor Symbol Sequencing* — said to involve the premotor region of the left hemisphere of the brain, and enable us to learn motor plans to consistently and sequentially produce a set of symbols (e.g., alphabet letters or numbers). This is remedied by a tracing exercise using pen and paper, where the student is to wear an eye patch over his or her left eye apparently to stimulate the left-hemisphere motor area. After remediation, the student may show improved reading tracking and potentially even an improved ability to use binocular vision cues.

(2) *Symbol Relations* — said to involve the juncture of the occipital-parietal-temporal areas in the left hemisphere of the brain. A deficit in this area may show itself as a propensity to reverse letters (b/d, p/q) and find it difficult to read an analogue clock. Grammar (especially prepositions) may also be difficult to understand. The Arrowsmith programme seems to target this deficit with the 'clocks' exercise, where the student must input via a keyboard the time displayed on a computer-drawn clock, which may have many different (certainly more than three) hands. There are apparently fourteen different rules to the clocks exercise.

(3) *Memory for Information or Instructions* — said to involve the temporal region of the left hemisphere of the brain. This deficit shows itself as difficulty in remembering and following lectures and conversations or instructions. These may have to be repeated several times before someone with this deficit can retain them. The deficit is remedied by an auditory exercise where the student must listen over and over to song lyrics until he or she can repeat them. The lyrics to be remembered get progressively more complex as the exercise continues.

(4) *Predicative Speech* — a deficit in which means you cannot learn the rules governing sentence structure, leading to a propensity to speak and write in short sentences. This deficit may further make it difficult to anticipate the consequences of words and actions and so someone suffering from it may appear to be rude or lacking tact. It is remediated through an auditory exercise where the student must listen to simple but correct speech (becoming progressively more complex) which he or she has to accurately repeat.

(5) *Broca's Speech Pronunciation* — a weakness in Broca's area is said to lead to a propensity to mispronounce words (and thus often restrict spoken vocabulary to simple words). Further, sufferers of this deficit may find it hard to talk and think at the same time. It is to be remedied by a vaguely described process where the student listens to sounds that make up words (phonemes), then 'holds on to' and repeats them, plays with them and shifts the emphasis placed on each.

(6) *Auditory Speech Discrimination* — said to involve the superior temporal region in the left hemisphere. A deficit in this area affects its sufferer's capacity to distinguish between similar sounding words (e.g. fear/hear, doom/tomb). It is not clear how this is to be remedied.

(7) *Symbolic Thinking* — said to involve the left prefrontal cortex. A deficit in this area affects its sufferer's capacity for mental initiative, and s/he has difficulty developing strategy for studying, is easily distracted and appears to have a short attention span. Again it is not clear how this is to be remedied.

(8) *Symbol Recognition* — said to involve the left occipto-temporal region. A deficit in this area causes difficulty in recognising and remembering words and symbols, meaning the sufferer has to study a word many more times than average before s/he can memorise it, finds learning sight words difficult, and is therefore slow to learn to read and spell. It is remediated through a computer-based symbol recognition deficit exercise where the student must look at and remember (progressively increasing) numbers of symbols from other languages (e.g., Arabic, Urdu).

(9) *Kinaesthetic Perception* — said to involve the somatosensory area in the parietal lobe. This deficit causes suffers to bump into objects with the affected side of their bodies, and may affect their handwriting (causing in particular uneven pressure and a tendency for their writing to wander off the line). Remediation for this deficit is

vaguely described, but is said to involve performing precise movements with the eyes closed.

(10) *Kinaesthetic Speech* — this deficit causes a lack of awareness of the position of the lips and tongue, resulting in slurred speech. Remediation for this deficit is again vaguely described but may involve speaking tongue-twisting word combinations.

(11) *Artifactual Thinking* — said to involve the right prefrontal cortex, this deficit is necessary to interpret emotions and modify behaviour accordingly. It is to be remediated by a process where the student must examine narrative art and come up with a hypothesis that makes sense.

(12) *Narrow Visual Span* — said to involve the occipital lobe, this capacity is responsible for the number of symbols or objects one can see in a single visual fixation. When restricted, the sufferer cannot see whole words in a single visual fixation. Remediation for this deficit is unclear.

(13) *Object Recognition* — said to involve a network of right hemisphere areas which allow us to recognise and remember details of visual objects, including faces. A deficit in this area means the sufferer takes longer to recognise and locate objects. It is remediated through a process where the student must memorise a particular image, then pick it out from a display of similar images.

(14) *Spatial Reasoning* — said to involve the right parietal area of the brain. This is the capacity to imagine a series of moves through space before executing them. A deficit here means the suffer cannot map out how to get from one place to another or mentally rotate maps. Such a deficit is remediated using a tracing exercise.

(15) *Mechanical Reasoning* — said to involve the right hemisphere. A deficit with this capacity causes difficulty in understanding how machines operate and how their parts interact. It may also cause difficulty using tools. It is not clear how this is to be remedied.

(16) *Abstract Reasoning* — again said to involve the right hemisphere. A deficit here causes trouble carrying out a sequence of steps in a non-language-related task. It is not clear how this is to be remedied.

(17) *Primary Motor* — said to involve the primary motor strip behind the prefrontal cortex. A deficit with this capacity interferes with the speed, strength and control of muscle movements on one side of the body or the other. The remedy is vague, but appears to involve exercise involving fast movements from one position to another.

(18) *Supplementary Motor/Quantification* — said to involve an area in the parietal lobes related to understanding quantity and number. This deficit is remediated through the student performing repeated and progressively more difficult mental calculations (e.g. addition/subtraction).

(19) *Lexical Memory Difficulties* — said to involve an area behind Wernicke's area devoted to remembering the sounds of words. This appears to be remediated by the student memorising poems following a specific procedure.

Evidence for efficacy:

Research in support of Arrowsmith's efficacy is presented in their document entitled "Academic Skills and Learning Outcomes" (Arrowsmith, n.d.). However, it is important to note that this research appears to be neither published in journals nor peer-reviewed. It includes:

- A *Report on the Toronto Catholic District School Board (TCDSB) Study of the Arrowsmith Program for Learning Disabilities* (January 2003) where researchers compared achievement on ten measures of academic skills and two measures of intelligence of 30 students in the Arrowsmith programme with 10 students undergoing 'traditional' special education. While none of the students in the traditional special education programme made significant progress beyond their performance at entry, all of the Arrowsmith students showed increased academic performance. One third of these students "were on a course of accelerated academic achievement that brought them closer to their non-LD peers." (p. 9)
- A follow-up *Report on the Effectiveness of the Arrowsmith Program in the Toronto Catholic District School Board* (January 2007) where researchers found an increase in the rate of acquisition of academic skills (word recognition, arithmetic, reading comprehension and reading speed) measured pre and post one year in the Arrowsmith Programme, a reduction in the quantity of resource support required, and changes in parent, student and teacher behaviour ratings.
- A *Report on an Outcome Evaluation of the Arrowsmith Program for Treating Learning Disabled Students* (November 2005) where researchers studied 79 children across three years and found that on a composite measure of six academic skills, students in the Arrowsmith programme moved from displaying below average performance pre-intervention to average performance after three years. They also found that improvements in particular Arrowsmith cognitive exercises were related to improvements on relevant academic skills measures – e.g., improvement on the symbol recognition task correlated with improvements on vocabulary, spelling, word attack and word recognition measures.
- Case-study cognitive score data (e.g. Woodcock-Johnson III) from the Eaton Arrowsmith School and the Eaton Learning Centre.

A number of further studies, which aim to be published in peer-reviewed journals, are underway according to the "Arrowsmith Research Initiatives Report" (Arrowsmith, 2014). These include studies measuring performance on the Woodcock-Johnson III test undertaken by the Brain Gain Lab at the University of Calgary and imaging studies taking place at the University of British Columbia and at the University of Southern Illinois.

Anecdotally (e.g. as presented in Arrowsmith-Young's book) many parents are highly praiseworthy of the effectiveness of the Arrowsmith programme.

Evidence against efficacy:

The Arrowsmith programme claims to be founded on neuroscience research. This is true in the sense that Arrowsmith-Young continually refers back to localisation of (dys)function as described by Luria when describing the development of her cognitive exercises. However, it is not the case that (present) neuroscience research actually supports the use of Arrowsmith's particular exercises to remediate learning disabilities. The Arrowsmith programme may have overzealously "filled in the missing research gaps" (Alferink & Farmer-Dougan, 2010, p. 48) between our understanding of the function of particular brain areas and how their activity relates to, and can be modified by, particular cognitive processes.

Price:

According to The Parent Room (n.d.), approximately $15,000 per student per year.

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B Brain Gym

Website / for more information see:

http://www.braingym.org/about; for details on the 26 exercises: http://www.healthythyroidcenter.com/therapy/braingym/movements.html.

What it involves:

Brain Gym, created by Paul and Gail Dennison, is a form of 'Educational Kinesiology' or 'learning through movement'. The programme primarily involves performing 26 movements/exercises, and progression through the programme involves building on these 26 activities. These movements include:

(1) *Cross-Crawl*

The individual stands with their feet hip distance apart and thinks of their body as a "big X". They slowly bring one arm down while moving the opposite leg up to meet it, then do the same with the opposite arm and leg. It is claimed that the slow contralateral movement activates the speech and language centres of the brain.

(2) *Sit-Up Cross Crawls*

The individual lays face up with knees bent towards the head and feet off the ground. Hands are behind the head, which is lifted a few inches off the ground. They have to slowly bring one elbow and the opposite knee together. Then, while bringing the elbow and knee away from each other, they repeat with the other elbow and knee. It is claimed that this enables the left and right hemisphere of the brain to work together.

(3) *Think of an 'X'*

The individual is told to close their eyes and imagine looking at a big X, or look at a drawn large X on a blank sheet located right in front of them. It is claimed that imagining or looking at an X strengthens the neural connections between left and right hemispheres, and this enables an "understanding of details and the big picture".

(4) *Lazy 8's*

The individual sits at a table with a large piece of paper in front of them (in landscape position). They then draw an infinity 8 symbol on the paper, starting from the centre and going up and to the left and ending at the centre. They must repeat this at least 3 times and always follow the pen/pencil tip with their eyes. It is claimed that this movement helps the eyes move together and integrates the left and right hemispheres of the brain.

(5) *Alphabet 8's*

The participant does the same thing as they did in the Lazy 8 exercise, but after tracing the 8 infinity symbol 3 times, they draw letters of the alphabet (all lowercase), starting at a and proceeding to z. After drawing each letter, the participant has to retrace the infinity symbol for another 3 times.

(6) *The Elephant*

The individual must stand with their feet hip width apart, left hand on hip and right arm straight up and touching the side of their head. They then bring their left arm in front of them, perpendicular to their torso, and are told to look at their middle finger while imagining a line extending straight out from its tip. The individual must then make an infinity symbol with their extended hand, moving using their whole torso, and notice the objects furthest in the distance that their middle finger points to as they draw the infinity symbol. They must do three infinity symbols with one arm before repeating the same with the other arm. It is claimed that this exercise improves attention, recognition, perception, discrimination and memory.

(7) *Double Doodle*

Using an easel with a large piece of paper or a whiteboard, the participant has to draw a line down the middle of the paper/whiteboard (this must be in line with the middle of their body). Then taking a pen/pencil in each hand, located the same distance apart from the middle line, the participant draws the same shapes simultaneously with both pens while looking straight ahead. It is claimed that the exercise is good for hand-eye coordination, spatial awareness, visual discrimination and creativity.

(8) *Neck Rolls*

Standing or sitting, the participant turns their head to one side and takes a deep breath. They slowly exhale for 8 seconds while bringing their head down and to the other side. When their head is on the opposite side, they take another deep breath and repeat the movement. This continues for a total of three times in each direction. It is claimed that the exercise allows individuals to concentrate visually on tasks by releasing neck tension, improves vision and hearing through muscle relaxation and greater blood flow to the head, and "centres, grounds and relaxes the central nervous system".

(9) *The Owl*

Either standing or sitting, the participant brings one hand up to their opposite shoulder and pinches the trapezius muscle between the neck and shoulder. They must then turn their head toward the same side as where their hand is pinching and breathe deeply. Then, while slowly exhaling for 8 seconds, they have to bring their head down and around to the other side. The individual must then bring their head back to the starting position, but facing the gripping hand. Once this is complete, they take another deep breath and repeat the head turn as they breathe out. This is repeated one more time. Then facing directly in front, the individual must take a deep breath and exhale slowly while bringing their chin down (repeating this two more times). All the actions are then repeated with the opposite hand. It is claimed this helps to release tension, increase the participant's range of motion, and improve their focus, attention and memory.

(10) *The Rocker*

Sitting on the floor, the individual must lean back into their arms and bring their bent knees up, then cross their ankles. They must then make circular or infinity movements with their tailbone. It is claimed that this improves posture, stabilises the pelvis, increases energy and improves focus.

(11) *Belly Breathing*

Involves deep breathing. Hands are placed on belly while taking long breaths in and out. This is claimed to improve expressive communication, attention span and energy levels.

(12) *The Energizer*

Sitting in a chair with their hands rested on their knees, participants have to lean forward so that their head is between their knees. While exhaling slowly after taking in a deep breath, they have to slowly bring their torso up with their head being the last part to extend. As they fully exhale, participants can let their spine extend back as far as they comfortably can. This movement must be done for a total of 3 times. This is claimed to improve spinal mobility, flexibility, relaxation, posture, concentration, attention and breathing.

(13) *Arm Activation*

This involves arm stretches. The right arm is held straight up along the side of the head, while left arm is brought and left fingers are wrapped around the right arm. The right shoulder is lifted and the right arm is pressed against the left fingers for 8 seconds. This is repeated for two more times with the same arm, then arms are switched and the same movement is repeated. It is claimed this can enhance one's ability to express ideas and one's focus, concentration, breathing and relaxation.

(14) *Foot Flex*

Sitting down, the right ankle is brought over the left knee. The participant squeezes and holds the tight muscles on the back and inside of the calf with their right hand and also squeezes and holds the Achilles tendon with the left hand. Then, while exhaling slowly for 8 seconds, the participant flexes their foot as far as comfortable and releases. This is repeated two more times and is then done again using the opposite hands and legs. It is claimed this can improve posture, relaxation and social expression and response.

(15) *Calf Pump*

Facing a wall, the participant leans forward and places their hands flat on the wall. They then move their right leg back with only the balls of their right foot and toes on the ground and their weight on the left leg. While exhaling for 8 seconds, they bring their right heal down to the floor, relax and bring the heel back off the ground. This is also repeated with the left leg, with the movement done for a total of 3 times for each leg. It is claimed this exercise can "improve social behaviour by increasing attention span and the ability to express and respond".

(16) *Gravity Glider*

While sitting in a chair, participants bring their legs out in front of them and cross their ankles (right over left). They then breathe in deeply and while exhaling for 8 counts lean forward slowly with their arms stretching towards their feet. This step is repeated two more times and is done again with the left ankle over the right ankle. This is claimed to improve posture, increase blood and oxygen flow, and improve confidence, stability and self-expression.

(17) *The Grounder*

Standing on a flat surface, the participant stretches their right leg out to the right side of their body while pointing their foot to the right. They then breathe in deeply and while exhaling (8 counts) bend their right knee and move to the right, stopping when the knee is directly over the foot. This is done for a total of three times and is also repeated with the left leg. This is claimed to improve whole-body relaxation, spatial awareness, comprehension, short-term memory and organisation.

(18) *Water*

Involves drinking water regularly.

(19) *Brain Buttons*

The participant stands with their feet hip width apart and one hand on their belly button. Forming a V shape with the thumb and fore and middle finger of the other hand, the participant massages the soft spots under the clavicle. While doing this, they also move their eyes from side to side and are told to notice what is in front of them with a soft focus. This is done for about 30 seconds with each hand. It is claimed that the exercise "supports left and right hemisphere connections through eye movements" and is good for relieving confusion or uncertainty.

(20) *Earth Buttons*

While either sitting or standing, the pointer and middle finger of the right hand is placed on the chin and the palm of the left hand is placed over the navel (with fingers pointing downward). The participant must then gently rub the chin and navel by moving their finders in a small, circular motion. While doing this, the participant also moves their eyes up and down while keeping their head still and breathing deeply. The same is repeated with hands switched. It is claimed this can improve mental alertness, grounding and whole body orientation.

(21) *Balance Buttons*

While standing with feet hip width apart, the right hand is placed over the belly, and the middle and pointer fingers of the left are placed on the temporal bone. The participant balances on their left leg for a count of eight and then switches to their right leg. While balancing on their right leg, the participant switches their hands so that the left hand is placed over the belly and the right fingers are on the temporal bone. Participants then balance on their left leg again. It is claimed that this improves one's sense of wellbeing, creates a more receptive attitude and improves reflexes.

(22) *Space Buttons*

Participants stand with their right leg in front of their left leg, their left middle and pointer fingers placed on the area between their nose and upper lip, and their right handle placed on the tailbone. While breathing, the left and right hands move in circular motions and the torso is bent so that participants are looking at their right foot "long enough to register that it is their foot". While still moving the fingers, the torso is brought up and participants look out to the farthest object that they can see and again "look at the object just long enough to register what it is". They then bend the torso back down to look at the right foot. This is done twice more and is repeated with the legs switched.

(23) *Energy Yawn*

The participant can stand, sit or lie face up. While opening the jaw in a long yawning motion, they massage the left and right jaw muscles with the respective middle and pointer fingers. This is repeated at least two more times. It is claimed this can relax the jaw, enhance creative expression visually and verbally and improve balance.

(24) *Thinking Cap*

While standing or sitting, the participant gently grabs the top of both ears with the thumb and pointer fingers. With slight pressure, they have to let the thumb slide up and out of the year before grabbing the part of the ear directly below the area that was being pulled. The thumb is then slid off the ear all the way down to the bottom of the lobe while giving the whole outer ear a massage. This is repeated at least two more times. It is claimed this can improve breathing, energy, focus attention, hearing, peripheral vision and equilibrium.

(25) *Hook-Ups*

Participants can stand, sit or lie down. The right ankle is crossed over the left ankle. The right wrist is crossed over the left wrist, with fingers interlocked and right wrist on top. Participants then bend the elbows out and gently turn the fingers towards the body until they rest on the sternum. They then breathe deeply while maintaining the position and placing the tongue on the roof of the mouth. To finish, the arms and legs are "un-hooked", the legs are kept hip distance apart, hands are placed at belly level and the position is held for about 8 seconds. This exercise is supposed to help to "connect the electrical circuits all over the body", thus enabling better focus and relaxation.

(26) *Positive Points*

Either standing or sitting down, the participant has their hands crossed in front of them and thumbs hooked together. All fingertips except thumbs are placed horizontally along the forehead. Hook-ups can also be done if desired. The position is held until "emotional stress is released". It is claimed that the exercise can relieve stomach aches, contribute to greater hormone regulation (apparently blood flow to the hypothalamus is increased) and contributes to more relaxed, clear thinking (apparently from increased blood flow to the frontal lobes).

Brain Gym is based on the notion that learning difficulties arise due to poor coordination and integration between different sections of the brain and body. Therefore, the exercises aim to improve the integration of specific brain functions with body movements. This idea draws from three main theories:

- *Neurological Repatterning*

  The 'neurological repatterning' theory is based upon the ideas of Doman and Delacato (as cited in Hyatt, 2007). The Doman-Delacato theory of development postulates that individuals must acquire specific motor skills at different developmental stages to ensure efficient neurological development; if motor skills associated with any of the developmental stages are not appropriately acquired, Doman and Delacato proposed that neurological development is hindered, consequently impairing learning. The Brain Gym exercises are supposed to mimic the stages of motor development in an attempt to master the movements at each stage. Brain Gym claims that this "repatterns neurons" so that the individual becomes "neurologically intact and ready to acquire academic skills".

- *Cerebral Dominance*

  This is based on work by Orton (as cited in Hyatt, 2007), who theorised that mixed cerebral dominance (i.e. left handedness, eyedness, footedness or mixed preference) was responsible for reading difficulties. Orton suggested that the most effective way to teach reading was to "integrate the right and left hemispheres of the brain by combining kinaesthetic and tactile learning strategies with visual and auditory exercises". This idea is reflected in several of the Brain Gym exercises.

- *Perceptual-Motor Training*

  The approach postulates that learning problems arise as a result of inefficient integration of visual and auditory perception with motor skills. Therefore, remediating learning problems would involve training the appropriate perceptual skills, which supposedly enables the child to overcome their learning deficits.

What claims does the company make / what does the programme target?

According to the Brain Gym website, the programme can be used "by people of all ages and abilities for a variety of reasons". The programme is allegedly effective in school classrooms, and for children with special needs and learning disabilities. Brain Gym claims that the programme can also be used to help corporations, athletes and health professionals.

The specific areas that Brain Gym allegedly targets include concentration and focus, memory, academics (reading, writing, maths), physical coordination, relationships, self-responsibility, organisation skills and attitude. The website also notes that "it is not clear why these movements work so well". The website claims that the programme brings about "dramatic improvements" in these areas.

Evidence for efficacy:

These notes will only focus on peer reviewed articles, though this is limited for Brain Gym. Additional research has been conducted with Brain Gym, but has been published in the Brain Gym funded non-peer reviewed *Brain Gym Journal*.

Khalsa, Morris, & Sifft (1988):

Khalsa et al. investigated whether Brain Gym exercises and "repatterning" activities would affect the static balance of sixty 7 to 11 year old children with learning disabilities. Children were assigned to 1 of 3 groups:

- Movement Group: did four Brain Gym exercises (hook-ups, positive points, cross-crawl and thinking cap) for 5 mins, twice a day, 5 days/week for 6 weeks.
- Repatterned Group: received a 10 min individual session of combined arm and leg movements coordinated with specific eye movements prior to engaging in the same 6 week Brain Gym programme as the Movement Group.
- Control Group: received no exposure to any techniques.

Static balance was pre- and post-tested in each group using a modified version of the Stork Stand Test. The study found that there were no significant differences between groups prior to "treatment" (although in their discussion section, the authors say that one of the group's mean score was "well below those of the other two" — so there is some inconsistency in the reporting of results). Post-test results suggested that the repatterned group showed the greatest improvement, followed by the movement group and then the control group.

Limitations: training for the movement and repatterned groups was conducted by class teachers, but they did not specify how many or what the teacher:child ratio was; no academic measures were used; did not mention whether teachers received any training on procedures; did not say whether any procedures were used to ensure that training was reliable (e.g., did students know why they were doing the exercises? It is possible that some teachers may have told the students what the training's purpose was.); used gain scores as the dependent variable, which is said to have unknown reliability (Hyatt, 2007).

Sifft & Khalsa (1991):

60 college students (19-40 years) were randomly assigned to 1 of 3 conditions:

- Movement group: participated in 7 Brain Gym activities.
- Repatterned group: engaged in combined arm and leg movements coordinated with specific eye movements for 10 minutes prior to completing the same Brain Gym activities as the Movement Group.
- Control group: sat quietly for 10 mins.

Only one Brain Gym training session was administered. Subjects were pre- and post-tested on simple and choice response-time tasks.

The authors claimed that there was a significant difference in improvement between groups on the 4 choice task, with the repatterned group showing the most improvement, followed by the movement group and then the controlled group (see limitations below regarding these results). There were no significant differences between groups on the simple choice task. The authors say that this is evidence that educational kinesiology movements "can enhance performance after only one exposure" and argue that these results "support the notion that the Edu-K techniques may influence the processing capacity of the central nervous system through an integration of the hemispheric activity".

Limitations: no explanation of exactly how the movements are influencing the processing capacity of the central nervous system, conclusions seem a bit dramatised; no academic measures; no mention of whether procedures were in place to ensure reliability of training; gain scores used; did not determine if there were any pre-test differences in performance between the groups; claimed that the repatterned group showed the most improvement, followed by the movement group and then the control group — however, Hyatt (2007) notes that no interaction effect was found — just a main effect of testing time, which indicated that the response times of all three groups had decreased: therefore, we cannot actually attribute the results to the intervention.

De Los Santos, Hume, & Cortes (2002):

The article is primarily concerned with increasing the success of Hispanic students in higher education. An "empirical case" using Brain Gym as well as classical music experience on younger, primary school students is given as an example of a "learner oriented technique that appears promising for Hispanic students". Students from low-achieving pilot (*n* = 398) and control (*n* = 596) schools, both of which had 99% Hispanics in the school population, were recruited to participate in the study. The pilot school used an "I Am Smart" programme, which involved experiencing classical music and Brain Gym exercises (20 mins/day) over the Spring semester. The control school continued with their regular academic programme. Pre and post measures were all teacher rated.

The study found that 3rd, 4th and 5th graders (combined) from the pilot school showed greater improvement in reading, writing and maths than those from the control school. Additionally, both 1st and 2nd graders from the pilot school showed greater increases in a measure of academic achievement (Iowa Test of Basic Skills) than those from the control school.

Limitations: authors did not mention whether procedures were in place to ensure training fidelity; comparisons were made but authors did not mention what tests were done and whether these were statistically significant.

Note: while these studies have been in the "Evidence for Efficacy" section, it is important to note that they are not of good quality. Spaulding, Mostert and Beam (2010) looked at whether these studies met Essential and Desirable Quality Indicators necessary to be considered high/acceptable quality, and found that none did. In addition, only the study by De los Santos et al. looks at academic achievement. Hyatt (2007) also noted that both the Khalsa et al. and Sifft & Khalsa studies were published in a journal whether authors pay for publications.

Evidence against efficacy:

Hyatt (2007); Spaulding et al. (2010):

Hyatt and Spaulding et al. both critically review the (somewhat limited) Brain Gym literature and its theoretical foundations. Criticisms regarding the studies evaluating Brain Gym's efficacy have been included in the limitations for each study above. Regarding Brain Gym's theoretical foundations, both articles mentioned several points of concern:

- *Neurological Repatterning*

  Hyatt (2007) noted that several organisations (American Academy for Cerebral Palsy, American Academy of Neurology, American Academy of Pediatrics, American Academy for Physical Medicine and Rehabilitation, American Congress of Rehabilitation Medicine, American Academy of Orthopedics, Canadian Association for Children with Learning Disabilities, Canadian Association for Retarded Children, Canadian Rehabilitation Council for the Disabled, and the National Association for Retarded Citizens) issued a combined cautionary statement regarding the Doman-Delacato procedures that Brain Gym is based on. Specifically, they stated that there were concerns with the procedures and its claims of success, despite the lack of supporting empirical evidence. Additionally, Spaulding et al. (2010) noted that several studies had invalidated the Doman-Delacato procedures even prior to the creation of Brain Gym.

- *Cerebral Dominance*

  In general, research has refuted the idea that cerebral dominance affects learning (see Hyatt and Spaulding et al. for cited studies).

- *Perceptual-Motor Training*

  Again, studies have not demonstrated that perceptual-motor training impacts learning (see Hyatt and Spaulding et al. for cited studies). In addition, Hyatt mentions that several organisations (The American Academy of Pediatrics, American Academy of Ophthalmology, and American Association for Pediatric Ophthalmology and Strabismus) have issued a combined statement strongly discrediting vision therapy (an area of perceptual-motor training that is incorporated in into Brain Gym).

Brain Gym has been referred to as "pseudoscience", particularly for its invalid theoretical assumptions and lack of good quality, peer-reviewed research. Indeed, an article by Lilienfeld, Ammirati and David (2012) used Brain Gym as an example of pseudoscience when discussing pseudoscience warning signs. It was criticised particularly for its lack of peer-reviewed research. Additionally, each of the 26 exercises claims to improve certain cognitive skills, but there is no evidence of exactly how these movements bring about these improvements.

Price:

Prices vary depending on the course selected, but an Introduction to Brain Gym course costs $145. See http://braingym.org.nz/sample-page/brain-gym-in-new-zealand/training-calendar/ for more info.

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C Cellfield

Website / for more information see:

http://www.cellfield.com/

What it involves:

Cellfield is based on the view that dyslexia arises possibly due to a combination of causes, and consequently targets several deficits concurrently. These deficits include phonological, visual and visual to phonological processing problems. The programme involves predominantly language tasks, and is computer-based, using computer game elements in its design. These tasks claim to employ reading related skills as well as attention, working memory and focus.

The Cellfield programme consists of ten one hour sessions over two weeks, which allegedly targets neural redevelopment. These sessions are generally comprised of ten exercises. Some exercises target phonological processing, and require concurrent activation of visual and auditory processing. Other exercises involve decoding and encoding activities e.g. finding text embedded in continuous random text with no spacing.

Cellfield also provides additional ten one hour sessions over a period of ten weeks, with supplementary guided reading at home. The programme involves "repetitive reading, tuition by exception, novelty and reward". These sessions aim to target consolidation and the transition into reading fluency. Children with more advanced reading disabilities may have to repeat Cellfield at a higher level 6 to 12 months after completing the initial intervention (there appear to be three levels to Cellfield: low, middle and high).

It is required that children who participate in Cellfield have at least some basic knowledge and skills (e.g. reasonable letter/sound correspondence skills). The company recommends that children who do not have these skills undergo conventional tuition prior to participating in Cellfield.

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Cellfield targets auditory, visual and visual to auditory processing problems. To improve these processing problems, letters, words and sentences that are presented on screen correspond to aural tasks that participants hear through earphones.

Additionally, approximately 30% of each session involves matching rhymes from a four word choice. Target rhymes are presented acoustically and visually for the first five sessions and only acoustically for the last five sessions. The target rhyme is also altered and presented with a stretch. This allows children with auditory processing problems to hear the word clearly. The degree of stretch is progressively reduced until children can clearly hear the words at normal speed for the last two sessions.

Each intervention session also allegedly includes exercises using "Pidgin English", which involves embedded text, and an exercise for homophones. Short, non-verbal exercises are also present in all sessions, and increase in difficulty during the duration of the programme. These components of Cellfield are said to be influenced by research indicating that visual and phonological factors play a role in developmental dyslexia (Prideaux, Marsh, & Caplygin, 2005).

Visual processing problems are addressed by motion graphics that are constantly moving across the screen, the design of which are based on an understanding of the neurophysiology of the transient vision system (Hart, as cited in Prideaux et al., 2005). The motion graphics are characterised by a complex combination of "contrasting edges, changing motion, velocity, dimensions". This is designed to stimulate the magnocellular pathways in the brain and is incorporated into each session.

Initially, the motion graphics are translucent and are constantly superimposed onto the letters, words and sentences on screen. When children reach the halfway point in the programme, the motion graphics become opaque and act as moving masks. Consequently, the tasks become more complex as they can only be performed by what is seen between the moving gaps. According to Cellfield, the motion graphics are designed as such to enhance the transient vision of the participants and to improve eye movement control, working memory, sequencing, peripheral vision and visual persistence.

Eye movement control has been linked to reading problems through deficits in fixation stability, where both eyes are aligned such that the centre of vision coincides with the fovea (Prideaux et al., 2005). There is fixation eccentricity (inability to achieve alignment) and fixation instability (able to achieve alignment but not hold a steady focus). Prior to participating in Cellfield, subjects undergo an orthoptic examination. Those who are found to show visual fixation/instability then use red lenses for some of the intervention sessions, as well as monocular occlusion for some of the initial sessions.

What claims does the company make / what does the programme target?

The programme is said to be suitable for children 8 years and over who:

- have a reading age that does not seem to be increasing and is falling behind their chronological age;
- have dyslexia;
- have been diagnosed with a language disorder;
- show difficulty in repeating orally given instructions;
- have poor reading, spelling and writing skills;
- have adequate phonological skills but not the required reading fluency, accuracy and comprehension;
- read at an age-appropriate level but cannot recall what they have read;
- feel discomfort/suffer from fatigue during reading;
- feel uncomfortable when looking at black letters on a white background;
- have problems controlling eye movements.

Cellfield also claims to be effective in improving several abilities, including attention, cognition, working memory, executive function, as well as auditory, ocular motor, visual, spatial and sequential processing. The company also declares that Cellfield can achieve average gain ratios of more than 20 in comprehension and word identification, 40 in decoding, more than 20 in reading accuracy and in a higher level of comprehension (note: gain ratios = increase in months per month of schooling; e.g., an improvement in reading by two months for every month of schooling is a gain ratio of 2).

The company also alleges that children who participate in the follow-on programme retain initial gains and improve at twice the learning rate of typical readers.

Evidence for efficacy:

Prideaux et al., 2005:

262 Australian school children aged 7 to 17 years participated in 10 intervention sessions at a Cellfield clinic for an average of 26 days between pre and post-treatment. 51% of these children were considered to be at risk of dyslexia, based on the Dyslexic Screening Test. Reading related skills were assessed using the Wide Range Achievement Test 3 (Reading and Spelling) and the Woodcock Reading Mastery Test-Revised (Word Attack and Passage Comprehension). Oral Reading Proficiency was measured using the third edition of the Neale Analysis of Reading Ability, with measures taken on reading speed, accuracy and comprehension. Measures of participants' visual performance in relation to their foveal position, foveal sensitivity and contrast sensitivity was scored prior to and following treatment by an experienced orthoptist.

Results:

- Reading Related Skills: a repeated measures MANOVA revealed that, on average, participants improved on all measures (reading, spelling, word attack and passage comprehension) from pre-test to post-test. A subsequent analysis accounting for dyslexia status found that while those at risk of dyslexia generally obtained lower scores on all measures than those not at risk at both pre- and post-test, both groups made the same relative gains. However, when controlling for verbal IQ, the study found that the change from pre-test to post-test for spelling scores was no longer significant (but remained significant for the other measures). Significant age norm increases for reading, word attack and passage comprehension were 1 month, 23 months and 12 months, respectively, for one month of intervention. Grade norm increases for word attack was 2 grades and 1.5 grades for passage comprehension.
- Oral Reading Proficiency: paired t-tests with Bonferroni corrections were conducted to analyse the data. The study found that there was a significant decrease in reading speed from pre- to post-test. In contrast, reading accuracy and comprehension significantly increased following treatment. This indicates a speed/accuracy trade-off. Observational records did note that following Cellfield, children did slow down and try to actively sound out the words in an attempt to decode them, and also engaged in more self-corrective behaviour.
- Ocular Measures: chi-square tests revealed that post-test frequencies for left and right eye foveal position, foveal sensitivity and contrast sensitivity significantly differed when compared to the expected frequencies, which were based on pre-test values. 90% of those who were assessed as having a foveal position off centre at pre-test were considered centred following treatment; averaged across left and right eyes, participants were 12 times more likely to be assessed as having a centred foveal position at post-test than at pre-test. 65% and 93% of those who had recordings of foveal instability and abnormal contrast sensitivity, respectively, prior to treatment showed readings within the normal range following Cellfield. Participants were 7 times more likely to show normal foveal stability and 19 times more likely to show normal contrast sensitivity at post-test than at pre-test.

Limitations: no comparison group was used. The generalizability of results may be a problem: the authors noted that a convenience sample was used (i.e. those seeking intervention for reading difficulties) and that Cellfield also requires some financial investment from the child's parents, thus participants in this study may not be representative of those who come from low income families or who are not interested in ameliorating reading problems. One of the authors, Dimitry Caplygin, is the inventor and Director of Cellfield, and therefore the study is not independent.

Evidence against efficacy:

Cellfield appears to be based on the magnocellular theory of dyslexia. This theory postulates that there are magnocellular abnormalities in sensory pathways in the brain (auditory, visual and tactile), and also argues that the cerebellum (and thus motor control) is impacted as it receives considerable input from several magnocellular systems (Ramus et al., 2003). The advantage of this theory is that it manages to account for all the deficits present in dyslexia. However, Ramus et al. note that this theory has received some criticism. Auditory deficits are not always present in individuals with dyslexia and do not seem to underlie their phonological processing problems. Similarly, visual deficits are not always present in dyslexic individuals, and those with visual impairments have appear to have problems with a range of stimuli, including those that do not tap into the magnocellular system. Therefore, the theory that Cellfield is based on is still debatable (see Ramus et al., 2003 for more details).

The study by Prideaux et al. (2005) is the only peer-reviewed study about Cellfield. For an intervention programme to be scientifically valid, it needs to be based on theory *and* empirical results. Unfortunately, one study is not sufficient in providing the programme with empirically-validated results, and thus we cannot comment on the programme's efficacy. While Cellfield sounds promising, its lack of peer-reviewed research is a major limitation.

Price:

Set prices for the programme were not available from the Cellfield website or from any Cellfield provider. A Cellfield pre-test appointment at a Hawkes Bay optometry clinic costs $295 (http://www.shattky.co.nz/visionlink/testimonials/cellfield/index.htm), but it is possible that the cost of the programme itself may vary depending on the nature of the child's learning difficulties.

References:

Prideaux, L., Marsh, K. A., & Caplygin, D. (2005). Efficacy of the Cellfield intervention for reading difficulties: An integrated computer-based approach targeting deficits associated with dyslexia. *Australian Journal of Learning Disabilities, 10*(2), 51–62. doi:10.1080/19404150509546789.

Ramus, F., Rosen, S., Dakin, S. C., Day, B. L., Castellote, J. M., White, S., & Frith, U. (2003). Theories of developmental dyslexia: insights from a multiple case study of dyslexic adults. *Brain, 126*(4), 841–865. doi:10.1093/brain/awg076.

D Cogmed Working Memory Training

Website / for more information see:

http://www.cogmed.com/ and http://www.pearsonclinical.co.uk/Cogmed/Cogmed-Working-Memory-Training.aspx.

What it involves:

Cogmed comprises three distinct online software programmes designed to increase users' working memory capacity. These are Cogmed JM for pre-school children, Cogmed RM for school age children and Cogmed QM for adolescents and adults. All three programmes consist of approximately 25 sessions. They are designed to generally be used 5 days per week and thus completed in a five week period.

<u>Cogmed JM</u>

Sessions last 15-20 minutes each. Activities include:

- *Rollercoaster, Hotel Pool* and *Twister*, which are essentially variations on the same task. A number of 'furzies' are shown in a fixed arrangement. One or more then jump(s) up and down in a particular order, and the user must click on the furzies in the same order in which they jumped. The tasks primarily differ in the number of furzies displayed. *Rollercoaster* and *Hotel* each display 9 furzies, *Pool* displays 12, and *Twister* displays 16.
- *Bumper Cars*: 5 'furzies' are shown sitting in bumper cars that are continuously moving in a rink. One or more furzies then jump(s) up and down in a particular order. The user must click on the furzies in the same order in which they jumped.
- *Ferris Wheel*: 8 'furzies' are shown sitting in a continuously rotating Ferris wheel. One or more furzies then jump(s) up and down in a particular order. The user must click on the furzies in the same order in which they jumped.
- *Animals*: 8 pictures of animals bordered by light bulbs are presented arranged in a circle. A number of animal pictures are then highlighted in a particular order by the bulbs bordering them lighting up. The user must then click on the animal pictures in the same order in which they were highlighted.

<u>Cogmed RM (also known as "RoboMemo")</u>

Sessions last 30-45 minutes each. Activities include:

- *Space Whack*: a number of craters under which monsters live are shown to the user, who is told that before a monster appears there will be a puff of smoke emitted from its crater. Puffs of smoke are then emitted from certain craters. To kill the monsters and complete the task, the user must position his/her mouse over the craters in the same order as the puffs of smoke were emitted.
- *Data Room*: the user is shown a number of lamps arranged in a 3-D grid (as if looking into a room without a ceiling). A number of lamps then light up in a particular order. The user must click on the lamps in the same order in which they lit up.
- *Decoder*: a sequence of letters is read to the user, with separate lamps lighting up each time a letter is read. Then, under each lamp, three different letters are presented. The user must click on the letter which corresponds to the one read out when that lamp was lit up.
- *Asteroids*: floating asteroids are shown to the user. A number flash in a particular order. The user must then click on the asteroids in the same order in which they flashed.
- *Space Cube*: a floating cube with 3 faces and 12 individual panels visible is shown. A number of these panels light up, with the cube rotating a small amount each time a panel lights up. The user must then click on the panels in the same order in which they lit up.
- *Numbered Grid*: a grid with 16 latches (4 x 4) is shown. Some of these open to reveal numbers, presented out of order (e.g., a 2, then a 1, then a 3 is revealed). The user must click on the latches in numerical order (i.e., 1, then 2, then 3), not simply in the order in which they were first opened.

- *Input Module*: a sequence of numbers is read out, corresponding to keys that light up on a keypad. The user is required to input the numbers into the keypad in reverse order.
- *Input Module w/ Lid*: this is the same as the *Input Module* task except that the user cannot see the keys light up when the numbers are read out.
- *Rotating Dots*: 10 lamps are shown in a continuously rotating wheel. A number of the lamps then light up in a particular order. The user must click on the lamps (now in a new position) in the same order in which they lit up.
- *Visual Data Link*: a grid with 16 lamps (4 x 4) is shown, with a number of them then lighting up in a particular order. The user must reproduce the sequence by clicking on the in the same order in which they lit up.
- *Rotating Data Link*: this is the same as the *Visual Data Link* task, except that after the lamps light up, the grid is then rotated 90°. This means that when the user is required to reproduce the sequence, the lamps are in a new position.

<u>Cogmed QM</u>

- *Cube*: essentially the same as the *Space Cube* task in Cogmed RM.
- *Sort*: essentially the same as the *Numbered Grid* task in Cogmed RM.
- *Assembly*: essentially the same as the *Decoder* task in Cogmed RM.
- *Rotating*: essentially the same as the *Rotating Dots* task in Cogmed RM.
- *Numbers*: essentially the same as the *Input Module* task in Cogmed RM.
- *Hidden*: essentially the same as the *Input Module w/ Lid* task in Cogmed RM.
- *Grid*: essentially the same as the *Visual Data Link* task in Cogmed RM.
- Twist: essentially the same as the *Rotating Data Link* task in Cogmed RM.
- *3D Grid*: very similar to the *Data Room* task in Cogmed RM. A number of panels in a 3-D grid (as if looking into a room without a ceiling) light up in a particular order. The user must click on the panels in the same order in which they lit up.
- *Chaos*: similar to the *Asteroids* task in Cogmed RM. Floating, continuously moving shapes are shown to the user, with a number flashing in a particular order. The user must then click on the shapes in the same order in which they flashed.

All three programmes feature an algorithm which continually adjusts the difficulty of the working memory task presented in order to ensure that the user is always performing at the limit of his or her (present) working memory capacity. When the user repeatedly gives correct responses, the task is modified to make it more difficult. Similarly if the user repeatedly gives incorrect responses, the task is modified to make it easier. The ostensible logic behind this is that cognitive resources can — much like muscles — be trained by repeated use near or at their full capacity (Melby-Lervåg & Hulme, 2013). There is at least some evidence that this may be the case (Diamond & Lee, 2011; Holmes, Gathercole, & Dunning, 2009; Klingberg et al., 2005).

What claims does the company make / what does the programme target?

Cogmed focuses on improving working memory capacity as, according to its website, "[p]oor working memory is the source of many problems related to attention and is often linked to ADHD, and other learning disabilities." (Cogmed, n.d.-a, Question 5) Throughout its website are claims that Cogmed is "evidence-based" (Question 1) and "[b]ased on solid research"

(Question 11), that it is "developed by leading neuroscientists" (Question 8), and that "Cogmed is dedicated to providing only products that are proven to be effective in rigorous research." (Question 8)

In their information document Cogmed Claims & Evidence (n.d.-b), Cogmed's developers do claim that their product can improve the inattentive and hyperactive symptoms of those with ADHD, but acknowledge that it does not constitute a cure. They also claim that Cogmed can lead to improved academic performance, but acknowledge that more research involving post-intervention reassessment is required.

Cogmed's developers claim that improvements in users' working memory and other behavioural outcomes are sustained over the long term. They are careful to point out, however, that they do not claim these gains will last forever, or that use of Cogmed will certainly result in a student getting better marks at school.

Evidence for efficacy:

There is undoubtedly a substantial volume of research investigating the efficacy of Cogmed, considerably larger than that investigating any of its competitors (Shipstead, Hicks, & Engle, 2012).

A large number of studies suggest that Cogmed training can indeed increase working memory capacity, at the very least in the short term (see generally the review of Rabipour & Raz, 2012 and (as examples) the experimental work of Brehmer, Westerberg and Bäckman, 2012; Holmes, Gathercole, & Dunning, 2009; Klingberg, Forssberg & Westerberg, 2002; Klingberg et al., 2005; Roughan & Hadwin, 2011). Further, some research suggests that such increases in working memory persist across time (Holmes, Gathercole, & Dunning, 2009; Klingberg et al., 2005; Roughan & Hadwin, 2011). However in a recent meta-analysis, Melby-Lervåg & Hulme (2013) suggested that it may be only improvements in visuospatial working memory which persist after training, with improvements in verbal working memory generally failing to persist.

A more contentious body of research suggests that Cogmed training can lead to improvement in other cognitive constructs, and that it may ameliorate the symptoms of ADHD and other learning disorders. A number of studies (Klingberg et al., 2002; Klingberg et al. 2005; Olesen, Westerberg, & Klingberg, 2004) suggest that Cogmed may improve reasoning ability as measured by Raven's Progressive Matrices, and attentional processes as measured by the Stroop Test. These results have not always been replicated in other newer studies, however (see e.g. Brehmer et al., 2012; Dahlin, 2011). Studies have also shown a reduction in the inattentive and hyperactive symptoms of those with ADHD undergoing Cogmed training (Beck, Hanson, Puffenberger, Benninger, & Benninger, 2010; Klingberg et al., 2002; Klingberg et al. 2005; Mezzacappa & Buckner, 2010), although significant reductions in symptoms tend to be based on the ratings of parents or teachers (see below for discussion about the lack of proper blinding in these studies). Klingberg et al. (2002) did find a reduction in hyperactive head-movements (an objective measure), although their results could not be replicated by Klingberg et al. (2005).

Few studies have directly examined Cogmed's impact on reading, or its efficacy as an intervention for dyslexia. One exception is the work of Dahlin (2011). She found that Cogmed training improved reading comprehension performance (although not word decoding or orthographic verification) in Swedish children with attentional deficits and other learning problems (NB: this was not a study limited to dyslexia). On the other hand, Holmes et al. (2009) found no increase in basic word reading after Cogmed training, but did find an improvement in mathematical ability at the 6-month follow-up point.

Evidence against efficacy:

There is considerable uncertainty about the neural correlates of any improvement in working memory capacity brought about by Cogmed working memory training. The two experiments detailed by Olesen et al. (2004) both showed an increase in activation in the prefrontal and parietal cortices of healthy adults, and a decrease in activation in their cingulate sulci (in their second experiment they also found increases in the thalamic and caudate nuclei and decreases in the inferior frontal sulcus and postcentral gyrus). Conversely Brehmer et al. (2011), who studied older (M = 63.7 years) healthy adults, found activity decreases in activity in the prefrontal, temporal and occipital cortices post-training and increases in activity in subcortical areas (thalamus and caudate). Crucially, they found that the magnitude of these neocortical decreases and subcortical increases correlated with the extent of the gain achieved during the intervention period. Indeed, if Cogmed training does work, it is not yet clear how it works. A similar conclusion — i.e., there is currently no clear pattern of neural change brought about by working memory training — was reached in a wider review incorporating studies using other working memory training programmes (Buschkuehl, Jaeggi, & Jonides, 2012).

Further, although there is a substantial *quantity* of research investigating Cogmed, various reviewers (e.g., Hulme & Melby-Lervåg, 2012; Melby-Lervåg & Hulme, 2013; Shipstead, Hicks, & Engle, 2012) have begun to question its *quality*. Together they identify a number of issues with studies cited supporting Cogmed's efficacy. These are:

- *Control group issues*: some studies wholly fail to include a control group (e.g., Holmes, Gathercole, Place, Dunning, Hilton & Elliott, 2010) meaning improvements between pre- and post-intervention testing may in fact be due to other changes within the time period (e.g., practice effects or regression to the mean). Of those which do include a control group, some fail to randomly assign participants to treatment and control conditions, meaning differences between the groups may be explained by pre-existing differences. Others use an inappropriate control procedure. If a study uses only an untreated control group (e.g., Roughan & Hadwin, 2011), then differences between the trained and control groups may be due to other, unforeseen effects of an intervention, such as those inducing expectancy effects or otherwise affecting motivation. To circumvent this, researchers (e.g. Holmes et al., 2009; Klingberg et al. 2002; Klingberg et al. 2005) have taken to using non-adaptive active control groups, where participants complete the same training except that the tasks do not become more difficult with repeated success. Nevertheless, Shipstead, Hicks, and Engle (2012) go further and criticise this approach also, arguing that participants in the two groups might still be differentially motivated to perform during post-intervention testing. Non-adaptive controls, they suggest, may not effectively convince participants they are in the process of cognitive training, and do not suggest to the user that his/her working memory is increasing. Arguably, their doubt is excessive, with some evidence suggesting that there is no difference in motivation between the groups, at least for young children (Bergman Nutley et al., 2011). Indeed, Jaeggi, Buschkuehl, Jonides & Shah (2012) suggest that the positive reinforcement control groups usually receive in terms of points earned is likely to be sufficient motivation.
- *Blinding and expectancy effects*: even if an active control is used, some studies fail to employ appropriate blinding, meaning their results may be confounded by expectancy effects. As one potent example, Cogmed's developers use the Beck et al. (2010) article to support their claim that Cogmed can reduce the inattentive and hyperactive symptoms of those with ADHD as measured by behavioural rating scales. In that study, the experimental group did indeed show a significant

reduction in ADHD symptomatology based on a series of parent-report scales. But neither participants nor parents were blind to treatment. Moreover, teachers, who were blind to treatment, reported no improvement in either executive functioning or ADHD symptomatology. Shipstead, Hicks, and Engle (2012) argue there is a pattern such that improved ADHD symptomatology is generally reported only in situations where raters are not blinded, and not in situations where they are.

- *Small sample sizes*: some of the earlier research which presented promising results involved limited sample sizes. For example, the second experiment reported by Klingberg et al. (2002) involved a treatment group of only four, and the first experiment reported by Olesen et al. (2004) involved a treatment group of only three.
- *Working memory assessment*: more varied testing is needed to provide robust evidence for increased working memory capacity after Cogmed training. Unfortunately, many studies reporting positive results use simple forward and backward span tasks to assess working memory, which are exactly what Cogmed uses for training (Shipstead, Hicks, & Engle, 2012). Their results may therefore (at least partially) represent the effect of task-specific practice. The results of studies which have used complex span tasks are mixed (Holmes et al., 2009; Holmes et al., 2010; cf Bergman Nutley et al., 2011; Shavelson et al., 2008). Further research using different types of working memory task is desirable. This, according to Shipstead, Hicks and Engle, could include not only complex span tasks but also visual arrays, running memory span, keeping track and free recall.
- *Generalizability*: reviewers have also doubted whether Cogmed generalises sufficiently to make it a worthwhile intervention. Again given the fact far-transfer effects have been found (as outlined above, e.g. improvements on the Stroop task and Raven's matrices) reviewers question the quality of those findings. As an example, a notable problem with studies finding transfer to the Stroop task is that they frequently use only incongruent trials (Klingberg, 2010). As Shipstead, Hicks and Engle point out, citing the work of Hutchison (2007) and Kane and Engle (2003), working memory capacity is in fact unrelated to performance on Stroop tasks involving only incongruent trials. Consequently, increased working memory capacity cannot readily explain increased performance on wholly incongruent Stroop tasks (although such increased performance could, as Jaeggi, Buschkuehl, Jonides & Shah, 2012 point out, result from other processes). Further, other studies have failed to replicate a transfer to the Stroop test (e.g. Brehmer et al., 2012, Dahlin, 2011; Westerberg et al., 2007) and to Raven’s matrices (e.g. Dahlin, 2011).
- *A lack of theory*: finally, reviewers have questioned the sufficiency of theoretical basis behind Cogmed’s claims. Even if we assume for this purpose that there are certain reliable generalizing effects, there is no solid theory to explain why these transfer effects occur (Jaeggi, Buschkuehl, Jonides & Shah, 2012; Hulme & Melby-Lervåg, 2012). More research is needed in particular to elucidate the relationship between attentional control and working memory capacity and training programmes.

In summary, despite the above, the overwhelming volume of research suggests that Cogmed certainly has the potential to improve performance on assessments of working memory. How far any improvements generalise is still not clear. For present purposes, it is important to note that there have been only isolated findings of transfer to reading (Dahlin, 2011) and mathematics (Holmes et al., 2009). As discussed above, detractors of working memory training suggest this is because working memory training does not affect any underlying neural substrate, but instead only stimulates the development of task-specific strategies which are not called on in everyday activities. A more optimistic interpretation is also possible, however. Such transfer failures may signal no more than a need to incorporate into Cogmed a wider, more-stimulating range of activities which explicitly allow users to practice transferring any newly-learned strategies to a range of other situations (Gathercole, Dunning, & Holmes, 2009).

Price:

According to The Parent Room (n.d.) website, $1475 privately and for schools, $3,600 for 10 students and 4 teachers.

A note about other working memory training programmes:

Cogmed — although the most researched — is not the only computerised working memory training programme for which there is support in the literature. Other working memory training programmes discovered during the audit are discussed briefly below.

Jungle Memory:

In contrast to Cogmed which uses simple span tasks for training, Jungle Memory (http://junglememory.com) uses three complex span tasks to train working memory. Users must recall visuo-spatial or verbal information which was presented as they performed word completion, mental rotation or mathematics tasks (Shipstead, Redick, & Engle, 2012; for a detailed description of each game see Alloway, 2012). Two studies support its efficacy. Both involve students with learning difficulties, and both use active control groups. They are:

Alloway (2012):

15 students (11.10 to 14.70 years old) with learning difficulties were randomly allocated to the treatment (n = 8) or control (n = 7) group. The treatment group trained on the three Jungle Memory exercises for 30 minutes three times per week for eight weeks. The control group received individualised targeted educational support for 30 minutes three times per week over the same eight-week period.

Pre- and post-intervention measures included the vocabulary test from the Wechsler Abbreviated Scales of Intelligence (WASI), the numerical operations test from the Wechsler Objective Numerical Dimensions, the spelling test from the Wechsler Objective Reading Dimensions and a self-developed computerised working memory assessment.

The treatment group improved across all measures, while the control group improved only in the spelling test. Mann-Whitney analysis of the differences between pre- and post-intervention scores revealed significant differences between the treatment and control groups' gains in the vocabulary, numerical operations and working memory measures, but no significant difference between the groups' changes in spelling scores.

Limitations: this was a pilot study with a small sample size.

Alloway, Bibile, & Lau (2013):

94 students with learning difficulties were allocated to one of three groups for the eight weeks of the study. The first group (n = 39) was the nonactive control. The second group (n = 32) was the active control, who trained using Jungle Memory, but only once a week. The third group was the treatment group, who trained using Jungle Memory four times per week.

Measures administered to all groups include the vocabulary test from the WASI, the spelling test from the Wechsler Objective Reading Dimensions, a test of arithmetic and fractions from the Wechsler Objective Numerical Dimensions and an updated version of Alloway's computerised working memory assessment (Automated Working Memory Assessment-II; AWMA). Measures were taken pre-training, immediately post-training, and eight months after training ended.

The nonactive and active control groups did not show significant improvements on any of the cognitive tests. In contrast, the treatment group showed significant improvements from pre-intervention to post-intervention in the working memory, vocabulary, and spelling measures, although not in the mathematics measure. They also showed a maintenance effect for working memory, vocabulary, and spelling at the eight-month follow up period.

These results suggest that the regularity with which cognitive training is undertaken is of great importance.

Odd Yellow:

Van der Molen, Van Luit, Van der Molen, Klugkist, and Jongmans (2010) report improvements in working memory, arithmetic and story recall in adolescents with mild to borderline intellectual disabilities who trained using a package developed by the researchers called 'Odd Yellow'. This involves one exercise where the user is shown sequences of three similar shapes on a computer screen. Two are identical in shape, and one is different. The shapes are black except for one of the two that are identical in shape, which is yellow. The user must identify the location of both the differently shaped and yellow figures for each sequence. The adaptive mechanism varies the number of sequences presented in each trial between one and seven.

Unfortunately, while interesting, Odd Yellow does not seem to be available for purchase by the public.

Lumosity:

Lumosity — which has its own section in this report — also incorporates some working memory training tasks.

Other, 'in-house' solutions:

Finally, given the focus of this report on specific learning disabilities, it is worth noting two studies where researchers have devised their own working memory training programmes and noted improvements in reading performance.

Chein and Morrison (2010) developed a working memory training programme where users trained on two adaptive complex span tasks. The first was a verbal task where users had to remember a series of letters which were presented between four seconds of lexical decision-making. The second was a spatial task where users had to remember the locations of stimuli which were presented between symmetry decisions. They found that healthy adults who trained using this programme improved significantly more than untrained controls in performance on working memory tests, the Stroop test, and the Nelson–Denny test of reading comprehension. Transfer to the ETS reading battery or Raven's matricies was observed.

Limitations: used a no-contact as opposed to an active control group and so does not account for Hawthorne effects.

Loosli, Buschkuehl, Perrig and Jaeggi (2012) developed a complex span task where the users were shown a series (which adaptively varied in length) of animal pictures. They had to decide whether each picture in the series was correctly oriented (i.e., whether were they upside down or not). Immediately afterwards they had to recreate the series of animal pictures from memory. They found that typically developing children who trained using this task for 2 weeks improved more than an untrained control group in measures of text reading and single-word reading, but not pseudoword reading.

Limitations: only quasi-experimental — participants not randomly matched to groups; used a no-contact as opposed to an active control group and so does not account for Hawthorne effects.

For an in-depth review of working memory training programmes and paradigms, results, and relevant methodological concerns, see Shipstead, Redick, and Engle (2012).

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E Coloured Overlays and Lenses (including those from Irlen and The Institute of Optometry)

Website / for more information see:

http://irlen.com/

http://www.ioo.org.uk/info0.htm

What it involves:

Various organisations, the best known of which are the Irlen Institute and The Institute of Optometry, make a series of coloured overlays and lenses, and provide an associated patented diagnostic and colour determination process. Together these are designed to treat (although not cure) a series of symptoms which the organisations claim form 'Scotopic Sensitivity Syndrome' or 'Irlen Syndrome'. The symptoms addressed can include light sensitivity, reading problems, discomfort (including glare from the page and headaches when reading), attention and concentration problems, writing problems, problems with depth perception, and distortions of words on the page. It is suggested by both organisations that individuals with undiagnosed Scotopic Sensitivity Syndrome may be misidentified as having a number of specific learning disabilities, dyslexia in particular.

What claims does the company make / what does the programme target?

On its website, Irlen (n.d.) claims that "[a]s many as half of the children and adults with perceptual processing problems are misdiagnosed with dyslexia. These individuals can be helped by the Irlen Method." Further, it is claimed that "[o]ften, a diagnosis of dyslexia assumes that children have difficulty with phonics. But when words jiggle, move, or disappear or when letters look like ants moving across the page, reading is so difficult that these children are labeled 'dyslexic.'" The claims of The Institute of Optometry are more moderate. It claims simply "children with reading difficulty are more likely than others to report visual perceptual distortion, and to benefit from coloured overlays".

Both organisations are careful, however, to disclaim that coloured overlays and lenses will not benefit all who have reading difficulties. They point out that those with "language-based dyslexia" (Irlen, n.d.) or those with "difficulties of a linguistic nature" (Institute of Optometry, n.d.) will need to address these problems separately.

Both organisations place great significance on their own diagnostic, colour determination and manufacturing processes, and claim that generic coloured overlays one might purchase elsewhere would not effectively treat Scotopic Sensitivity Syndrome (Hyatt, Stephenson, & Carter, 2009).

Evidence for efficacy:

There are a number of peer-reviewed studies suggesting coloured overlays may have a beneficial effect on reading rate for some people (Bouldoukian, Wilkins, & Evans, 2002; Northway, 2003; O'Connor, Sofo, Kendall, & Olsen, 1990; Scott et al., 2002; Wilkins, Lewis, Smith, Rowland, & Tweedie 2001), and some that suggest overlays may bring about improvements in accuracy and comprehension (O'Connor et al., 1990; Robinson & Conway, 1990; Robinson & Foreman, 1999). Interestingly, such improvements seem to be shown when participants themselves choose the colour of the overlay they use during the intervention (Wilkins, 2002).

Evidence against efficacy:

It is obvious that before the presence of a specific learning disability can legitimately be inferred, primary sensory impairments (of vision and hearing) must be ruled out. It is further not contentious that children with specific learning disabilities may have accompanying visual or perceptual problems. However, Scotopic Sensitivity Syndrome's existence is arguably not backed up by sufficiently objective scientific evidence, and its recognition is far from universal

(American Academy of Pediatrics, 2011; Helveston, 1990; Hoyt, 1990; Hyatt, Stephenson, & Carter, 2009). This is in fact acknowledged on The Institute of Optometry's website.

Even if Scotopic Sensitivity Syndrome does exist, evidence does not seem to support the claim on Irlen's (n.d.) website that "[a]s many as half of the children and adults with perceptual processing problems are misdiagnosed with dyslexia" (see also in Irlen & Lass, 1989). For example, Kriss and Evans (2005) found only that the difference in the prevalence of scotopic sensitivity syndrome in samples of dyslexic and non-dyslexic children did not reach statistical significance, and could conclude only that scotopic sensitivity syndrome "is prevalent in the general population and possibly a little more common in dyslexia" (p. 350).

Further, the results of studies investigating the efficacy of its treatment with coloured overlays are at best mixed, with no consistent pattern of results emerging (American Academy of Pediatrics, 2011; Hyatt, Stephenson, & Carter, 2009). Although some studies report promising results (see above), others find no significant differences between reading with and without overlays or lenses (Blaskey et al., 1990; Fletcher & Martinez, 1994; Gole et al., 2002; Martin, Mackenzie, Lovegrove, & McNicol, 1993; Menacker, Breton, Breton, Radcliffe, & Gole, 1993; Ritchie, Della Sala, & McIntosh, 2011; Saint-John & White, 1988). Reviewers (American Academy of Pediatrics, 2011; Hoyt, 1990; Hyatt, Stephenson, & Carter, 2009; Parker, 1990; Solan, 1990) have also drawn attention to the fact that many studies which conclude that treatment with coloured overlays and lenses is efficacious suffer from methodological issues, or are authored by those commercially involved with the particular intervention being evaluated (Wilkins, notably, receives royalties from the Medical Research Council for having invented the Intuitive Overlays and Intuitive Colorimeter). Particular methodological issues common to multiple studies include:

- the use of different reading and subskill assessments, improvement on which may not necessarily translate into improvements in reading in real life;
- a lack of adequate (and in some studies, any) control groups, leading to the possibility of strong placebo effects; and
- questionable statistical analyses, including analysis using ordinal scores, and analysis involving multiple statistical tests without correcting for false positives.

Finally, as noted by Wilkins, Sihra and Myers (2005) — who in fact support the use of coloured filters for reading — there is no theoretical framework that can adequately account for the (supposed) benefits brought about by coloured overlays/lenses. Theories of magnocellular deficits and cortical hyperexcitability have been posited, but neither can sufficiently explain the range of individual differences in optimal lens/overlay colours.

A balanced conclusion seems to be that although poor perception may interfere with reading in some cases, misperception is not the most common cause of dyslexic symptoms (the generally accepted view being that dyslexia results from a phonologic-deficit; see Shaywitz & Shaywitz, 2005) and, overall, there is little evidence for the efficacy of coloured overlays and lenses as an intervention for reading difficulties in most people. The scientific literature in this area shows no conclusive pattern and often suffers from methodological weakness. Nevertheless, it is still possible that further methodologically sound research may be able to identify a distinct subgroup of people who these techniques may reliably assist.

Price:

Pricing is somewhat variable and depends on who screens the patient, whether the patient chooses to use overlays or lenses, and what type of lenses the patient selects.

Example charges in the UK are available on this website: http://www.irlencentralengland.co.uk/costs.asp and in the US on this website: http://www.irlenvlcmd.com/screening-diagnostic/.

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F Danks Davis Dyslexia Tutoring

Website / for more information see:

http://www.danksdavisdyslexia.com/

What it involves:

NB: not to be confused with the Davis Dyslexia method.

Developed in New Zealand by Zannie Danks Davis, this programme uses one-on-one weekly 1-hour tutoring sessions to help children with dyslexia learn to spell, read and write. The sessions can be led by tutors, parents, or teachers, but all follow the same seven step method. A full description of the process is not provided to the public, but in summary involves (Danks Davis Dyslexia, n.d.):

Step 1: Brain Gym exercises "to open their learning channels".

Step 2: Assessment to create a list of words the student is unable to spell.

Steps 3 to 6: Multisensory instuction in spelling to learn the words identified in Step 2. Auditory perception problems will also be addressed.

Step 7: Testing to ensure the student has learned the words and understands how to use them.

The programme is based on Danks Davis' views and experience of how dyslexics learn, and (supposedly) on relevant educational research.

What claims does the company make / what does the programme target?

The programme targets spelling as the key target for literary success. It is claimed that gains should be seen in listening skills, comprehension, oral language, spelling, writing and reading. It is also claimed that gains may be seen in coding, digit span, and processing speed tasks as measured by the WISC-IV.

It is purportedly founded on educational research, but no specific research findings are mentioned.

Evidence for efficacy:

There appear to be no refereed studies investigating Danks Davis tutoring. All that is available in support of the method's efficacy is extracts from five educational psychologists' reports showing improvements after Danks Davis tutoring presented on the programme's website at http://www.danksdavisdyslexia.com/index.php?id=4.

Evidence against efficacy:

There is no evidence that the Danks Davis programme is effeective. It is not legitimate to infer from this that the programme does not work, but it cannot presently be recommended as an evidence-based programme.

Price:

The cost to purchase the Danks Davis manual and DVD is NZD $3000.00 + GST.

References:

Danks Davis Dyslexia. (n.d.). *The Seven Steps for Danks Davis Dyslexia Tutoring*. Retrieved from http://www.danksdavisdyslexia.com/index.php?id=3.

G Davis Dyslexia

Website / for more information see:

http://www.dyslexia.com/program.htm

http://www.davisdyslexia.co.nz/

What it involves:

The Davis Correction programme is roughly a 30 hour programme, generally completed within a period of one week. Each participant works individually with a licensed Davis facilitator. The New Zealand website also notes that the client can come back for up to 3 follow up reviews when needed.

More details on the methods in the Davis correction programme can be found in Ron Davis' book, *The Gift of Dyslexia*.

Davis Perceptual Ability Assessment:

Involves imaging a piece of cake (or cheese — something with a distinct shape) from different locations/perspectives. Davis says that this action involves "shifting the mind's eye". According to Davis, this assessment is used to determine whether a person has the ability to easily "move their mind's eye around".

Orientation Counselling:

The purpose of orientation counselling is to train the participant to turn disorientation (i.e. a multidimensional way of thinking/perceiving that enables the dyslexic to better understand the world, but also brings about dyslexic symptoms) on and off. When disorientation is turned off, the individual is said to have an accurate, consistent perception of the environment and this eliminates dyslexic symptoms. Orientation counselling primarily involves mental imagery to find the "orientation point" and "anchoring it in place" — which Davis claims turns disorientation off. The participant is then trained to control turning disorientation on and off and shifting back to orientation if something happens (e.g. a distraction) that causes disorientation. For more details, see *The Gift of Dyslexia*.

Release and Review:

This is for when the individual gets headaches from "holding" (according to Davis, holding is when the individual is attempting to move his/her "mind's eye" while simultaneously trying to prevent it from moving).

Release procedure: the participant makes a loose fist, then thinks "open hand" but instead makes the fist tighter. This is done twice more, each time making the fist even tighter. Then the participant releases the clenched fist "without a thought". Participant is told to be aware of the feeling of "release" going through the arm, hand and fingertips and that their mind's eye can have that feeling by "simply wanting to".

Orientation review: Davis claims that the "orientation point" established during initial orientation counselling may occasionally move, so a review is done to put it back in its original place. First the student identifies where their orientation point is, then adjusts their finger to where it should be.

Fine Tuning:

This is done to find the "optimum orientation point". According to Davis, the participant knows when this is found as they "will be perfectly balanced" and will "experience a profound sense of wellbeing". Fine tuning involves balancing on one foot and moving the mind around until the participant feels that it is on a point where their body is in perfect balance, then "anchoring" the mind's eye at this point. Fine tuning is done daily until the orientation point is reliably at its optimum point.

Koosh Ball Therapy:

According to Davis, this exercise is supposed to address coordination and dyspraxia problems. The facilitator stands 6-10 feet away from participant and checks that they are "on point". Once "oriented", the participant balances on one foot and has to catch 2 Koosh balls, one in either hand. The facilitator progresses from throwing the balls in sequence, to throwing them simultaneously, to throwing them only to one side of the body, depending on how easily student is able to catch the balls while maintaining balance.

Symbol Mastery:

This involves a multidimensional approach to learning trigger symbols and words, as participants develop and understanding of what the symbol/word looks like (spelling), sounds like (pronunciation) and what it means (picture).

- Uppercase and lowercase letters: the participant makes the letters out of clay and has them positioned and sequenced in the correct order. If mistakes are found, participant is told to make comparisons with examples, so that they can realise their mistakes and correct them. Participant then touches and says the letter of each alphabet in forward and backward order, looking when needed, until they are able to do so without looking. Facilitator then calls out a letter and participant must select the appropriate clay letter and say what letters follow and precede the target the letter. Symbol mastery is achieved when all exercises can be completed easily. The exercises starts with uppercase letters.

  Additional exercises: finding letters in surroundings, writing the letters and noticing the different print styles and typefaces.

- Punctuation symbols: the facilitator goes over the simple definition of each symbol with participant. The participant then makes the symbol with clay, writes the name of the symbol on a piece of paper, and places the clay form of the symbol in proper relation to the written form. The facilitator points out punctuation marks in text, and has the student do the same. The facilitator also goes over uses of the mark and has the student provide verbal and written examples of how each mark is used. They should also ensure that student knows how to pronounce the name of each symbol.

- Words: the participant looks up the word in a dictionary and learns how to pronounce it. The first definition of the word is read, and the participant makes up sentences/phrases with that particular definition. A clay model of the concept described by that definition and clay letters of the word are then made, allowing the participant to form a mental picture of what has been created. The participant then says the word and its definition aloud, and they may also touch and say the letters of the word or write the word if they wish. Davis recommends that when going through words on a list, the first definition of all words should be mastered before progressing through the list again and mastering additional definitions.
- Mastery of the pronunciation key in a dictionary, print styles and typefaces can also be achieved if needed. See *The Gift of Dyslexia* for more details.

Spell Reading:

Starting at a grade lower than what the child is at, the participant makes a word using clay. Then, the participant must spell and read each word. The aim to is to help participants recognise letters and words and train left-to-right reading

Sweep-Sweep-Spell:

The facilitator covers words in a line with paper, only revealing one word at a time. The participant must try to read each word. A word may be swept twice and if the participant still cannot read the word, then it has to be spelled and pronounced. The aim is recognition and training left-to-right reading.

Picture-at-Punctuation:

The participant reads a text up to punctuation and then explains what they have read. They are asked to form a picture in their mind of what they have read.

Orientation Counselling and Symbol Mastery are the key exercises in the programme. Davis recommends starting off with Orientation Counselling, followed by a reading exercise from Spell Reading to detect and correct disorientations. Release procedures are done when needed. Basic Symbol Mastery is done after Orientation Counselling, followed by Orientation Review and then Fine Tuning before proceeding. Davis also recommends alternating Symbol Mastery with the three aforementioned reading exercises (spell reading, sweep-sweep-spell and picture-at-punctuation). Following programme completion, the participant is advised to continue with Koosh ball therapy, the reading exercises and symbol mastery with clay.

Davis Maths Mastery:

Like with Dyslexia Correction, Orientation Counselling is also provided under the Maths Mastery programme. Clay modelling is also used for Symbol Mastery, but with a focus on numbers and mathematical symbols. It is unclear whether additional mathematical exercises are practised with the participants. According to the NZ Davis website, the programme usually takes roughly 5 to 8 days to complete, though less time may be required if the participant has already complete Dyslexia Correction.

Davis Attention Mastery:

Orientation Counselling is also provided within this programme. Additionally, the programme also involves Davis Concept Mastery, where clay is used to enable the individual to understand missing or misunderstood life concepts. Davis proposes that understanding these concepts allows the individual to better understand situations, apply the concepts to their daily life and improve behavioural choices. These concepts typically include: change, consequence, cause/effect, before/after, time, sequence, order vs disorder.

Davis Reading Programme for Young Learners:

This programme is aimed at children aged 5 to 7 years, and involves assistance from a facilitator as well as a parent/family member. It is based on the Davis Dyslexia Correction programme, but does not involve Orientation Counselling.

What claims does the company make / what does the programme target?

Ron Davis, the creator of Davis Dyslexia, claims that dyslexia is caused by a gifted ability that involves "utilising the brain to alter and create perceptions". In his book, Davis also claims that dyslexics think mainly in pictures (nonverbal conceptualisation), with little to no internal monologue, think and perceive multi-dimensionally, and experience thought as reality. The dyslexic symptoms occur as nonverbal conceptualisation cannot be used to understand certain words, as the individual has no image for it (e.g. word "the"), and this leads to confusion/disorientation. The Davis Programme claims to teach the students how to recognise and control the mental state that leads to this confusion, through Orientation Counselling, and gives them the ability to think about problem words, numbers etc. nonverbally (by forming a mental image using the clay modelling methods), thereby preventing the disorientation.

In addition to the Davis programme for reading and writing, there are also Davis programmes aimed at targeting dyscalculia (Maths Mastery), ADHD (Attention Mastery) and reading for younger children (Davis Reading Programme for Young Learners). Davis Dyslexia claims that younger children exposed to the latter Davis programme are highly unlikely to develop a learning difficulty, are significantly more likely to qualify for gifted programme referrals and will have very high levels of basic word recognition for their age.

According to the website, the Davis programme is suitable primarily for children 8 years or over and adults of any age. Davis' book suggests that symbol mastery methods can be used for children under the age of 8.

Claims to bring about improvement in spelling, reading, handwriting as well as self-esteem and confidence. The website also claims that the programme has a 97% success rate.

Evidence for efficacy:

Few peer reviewed articles have been published on the Davis Dyslexia programme, most of which are case studies. Additionally, several of these studies have been published in a non-English language, therefore these could not be reviewed. There were no peer-reviewed articles evaluating the efficacy of other Davis programmes (i.e. Davis Maths Mastery, Davis Attention Mastery, Davis Reading Programme for Younger Learners).

Pfeiffer et al. (2001):

Davis learning strategies were integrated into the reading programmes of 48 first grade children from 3 pilot classrooms. 48 students from control classrooms also followed the same reading programme as the pilot children, but without the use of any Davis learning strategies.

The Davis learning strategies involved training “focusing skills” (it is unclear whether this is like the Orientation Counselling) and Symbol Mastery.

Children were tested word recognition of 100 basic core words prior to training and following training at the end of the school year. Mann-Whitney U test results revealed that students in the pilot classrooms scored significantly higher on the control group for their word recognition. The study also notes that the pilot classrooms had no special education referrals made 2 years after Davis training, but did have greater gifted referrals made than would be expected in a typical high school population.

Limitations: did not look at whether other reading or language skills improved; although long term data was collected on special education and gifted referrals, no long term measures were taken on reading and language skills. As such, we cannot be sure whether the Davis learning strategies produced any lasting effects. The authors also do not discuss the special education and gifted referrals for the control classroom; unclear whether there were any pre-training differences between the pilot and control students.

van Staden, Tolmie, & Badenhorst, 2009:

This study aimed to address the impairments of 10-14 year old dyslexics through a community-based research project. Specifically, 8 Honours students in support teaching developed and implemented a literacy programme for intermediate dyslexics that were based on Ron Davis’ methods (Orientation Counselling and Symbol Mastery were included in the intervention programme). The experimental group (n = 18) received individual support from the Honours students once a week for 30 mins over a period of 9 months. The control group (n = 18) received individual support from their respective support teaching educators, also once a week for 30 mins over 9 months. The training for the control group focused primarily on the development of literacy skills using phonological methods.

Mann-Whitney U tests revealed that there were no significant differences between the experimental and control groups prior to training. However, following intervention, there were significant differences between the two groups on word recognition and spelling scores: the experimental group showed a significant improvement on both measures, whereas there was no change for the control group. Qualitative interviews also revealed that students showed improved concentration, better self-concepts and a reduction in speech and behaviour-related problems.

Limitations: sample size; did not provide much detail on the control group’s intervention, just that it focused on phonological processing.

Ambrose & Cheong, 2011:

This study specifically looked at the effects of Davis’ clay modelling methods with symbol mastery on the reading behaviours of three 13 year old dyslexic children. The programme was conducted for a total of 20 sessions, each approximately 75 mins, spanned over the course of 8 weeks. Sessions targeted symbol mastery of uppercase and lowercase letters, punctuation marks and words. Spell-Reading, Sweep-Sweep-Spell and Picture-at-Punctuation exercises were also used. The children were used as their own controls, with symbol mastery training used on one piece of text (Text 1) and no intervention administered for the other set of text (Text 2).

Results were presented in a case study-type format for each participant, thus no statistical tests were conducted. All participants were able to read Text 1 fluently, were able to spell words from Text 1 correctly, were more attentive in class and showed increased self-confidence (the latter two results were indicated by teacher reports). However, students still struggled with reading and spelling words from Text 2, suggesting that the improvements with Text 1 were due to the symbol mastery methods.

Limitations: sample size (and consequently lack of statistical analyses); subjective measures were used; no alternative treatment group and participants were used as their own controls;

Amsberry, McLaughlin, Derby, & Waco, 2012:

This was a case study, in which a 9 year old boy with significant learning disability underwent Symbol Mastery with different sets of words to address his spelling deficits. After symbol mastery for a set was completed, the participant was tested on spelling.

Results showed that spelling on the sets of words was low prior to training, but increased to 90% correct following training.

Limitations: case study; did not look at whether training benefits generalised to other language and reading skills; possible that repetition effects may have influenced results.

Evidence against efficacy:

There is evidence to suggest that visual images, e.g. drawings, can help recall (de la Iglesia, Buceta & Campos, 2005), therefore it is possible that clay modelling helps dyslexic children learn and remember words that they may struggle with. However, there is no evidence to suggest that dyslexics experience "disorientation" as Davis defines it or that they have a "mind's eye" that can be moved around to alter dyslexic symptoms. Davis also makes several claims about the abilities and experiences that dyslexics may have and what may underlie these experience, but fails to support these claims with evidence.

The limited number of peer-reviewed articles evaluating Davis Dyslexia generally have not focused on whether participating in the Davis programme resulted in improvements in more general reading/spelling abilities nor have studies compared Davis to alternative interventions (aside from van Staden et al., 2009). Additionally, several of these studies are case studies, and so there is a dearth of statistically significant results.

In sum, there is a lack of theoretical and high quality empirical evidence to support the Davis programme.

Price:

Between $2500 - $3000.

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H Dore Programme

Website / for more information see:

http://www.dore.co.uk/

http://www.dore.co.nz/

What it involves:

The Dore programme is a for-profit intervention targeting dyslexia, dyspraxia and ADHD involving particular physical exercises. Founded by businessman Wynford Dore, it is based on the theory that learning difficulties arise due to a single underlying cause located within the cerebellum (sometimes referred to as a cerebellar developmental delay).

While the Dore programme is proprietary and the specifics of its exercises are not available to the public, it is known to involve "use of a balance board; throwing and catching of bean bags (including throwing from hand to hand with careful tracking by eye); practice of dual tasking; and a range of stretching and coordination exercises" (Reynolds, Nicolson, & Hambly, 2003, p. 55). Exercises are done for ten minutes twice a day, with the programme taking about fourteen months to complete (Stephenson & Wheldall, 2008). Further description can be found in Appendix A of Reynolds and Nicolson's (2007) article "Follow-up of an Exercise-based Treatment for Children with Reading Difficulties".

Note: the Dore programme was previously referred to as 'Dyslexia, Dyspraxia and Attention Treatment' and the abbreviation 'DDAT' is consequently sometimes used in the literature.

What claims does the company make / what does the programme target?

Dore (n.d., para. 4) argues their "physical stimulation approach" will "improve cerebellar underperformance" and consequently address the underlying cause of learning and attention disabilities.

Evidence for efficacy:

There is some literature linking the cerebellum with learning disabilities, and in particular with dyslexia and ADHD. Most notably, Nicolson, Fawcett and Dean (2001) argue that children with dyslexia experience dysfunction well beyond difficulties with reading and spelling. Dyslexia, they argue, is instead more accurately characterised as a 'skill automatisation' disorder (skill automatisation being "the process by which, after long practice, skills become so fluent that they no longer need conscious control" (p. 508) "whether or not the skill is in the literacy domain" (p. 509)). They suggest its symptoms are – theoretically and empirically – best predicted by a cerebellar impairment hypothesis. They do so based on:

- behavioural testing data (Nicolson & Fawcett, 1994a; 1994b) suggesting children with dyslexia show generalised difficulties related to processing speed, memory, motor skill and balance;
- tests of cerebellar function (dystonia and dyscoordination), on which dyslexic children show impaired performance compared with controls matched for reading-age (Fawcett, Nicolson, & Dean, 1996; Fawcett & Nicolson, 1999);
- a PET study (that article) involving learning (by trial and error) a sequence of button presses, during which dyslexic participants demonstrated, compared with healthy controls, significantly reduced activation in the ipsilateral (right) hemisphere of the cerebellum; and
- MR spectroscopy data showing (p. 510) "differences in the ratio of choline-containing compounds to N-acetylaspartate (NA) in the left temporo-parietal lobe and the right cerebellum, together with lateralization differences in the cerebellum of the dyslexic men but not the controls" (Rae et al., 1998).

Moreover, there are two articles in peer-reviewed journals supporting Dore's efficacy for dyslexia. These (Reynolds, Nicolson, & Hambly, 2003; Reynolds & Nicolson, 2007) report the results of two phases of a Dore intervention trial at a primary school in Warwickshire. The 2003 study ostensibly found that children receiving Dore treatment demonstrated increased performance (relative to controls) in the number of words they could read in one minute, in semantic fluency, and in rapid naming. They also found Dore improved phoneme segmentation and nonsense passage reading, as well as SAT literacy scores for those in the treatment group. The 2007 study concluded that after an 18 month follow-up period gains were maintained (or improved) in semantic fluency, rapid naming and phoneme segmentation (note, however, there was no control group here, as those previously in the control group had subsequently been offered the Dore treatment). There was also an increase in the rate of improvement in reading age as measured by the NFER test. In contrast, improvements in speed reading or nonsense passage reading were not maintained over time. Note that, as is described below, both of these articles have been met with considerable criticism and should be interpreted carefully.

Evidence against efficacy:

There is not strong evidence that cerebellar abnormality plays a causal role in dyslexia. Given the cerebellum's plasticity, abnormal cerebellum structure or function may in fact be a marker indicative of more generalised abnormal early brain development, or a consequence of dyslexia (Bishop, 2002). Additionally, as Reynolds et al. (2003) themselves admit, it is generally thought the cerebellum is composed of many small and independent areas, and so it is not readily apparent why training on one task (in which certain zones are involved) should generalise to unrelated tasks.

Moreover, a number of other researchers are critical of the Dore intervention research carried out by Reynolds et al. (2003) and Reynolds and Nicolson (2007). The 2003 article was followed by nine critical commentaries (Hatcher, 2003; McPhillips, 2003; Peer, 2003; Rack, 2003; Richards et al., 2003; Singleton & Stuart, 2003; Snowling & Hulme, 2003; Stein, 2003; Whiteley and Pope, 2003), and its publication prompted one member of the editorial board of *Dyslexia* to resign. The 2007 follow-up prompted five further resignations (Bishop, 2007). Issues identified with the research include the following:

- *An untreated control condition, and no control condition for the 2007 follow-up study*: the authors consider but then reject using an active control group because "it is difficult to envisage just what such an activity would entail given the need for 180 separate parent-administered sessions over the 6 months" (Reynolds et al., 2003, p. 54), because doing so might lead to "boredom and alienation" (p. 54) and therefore inflate the outcomes of Dore treatment, and because doing so would in their view be problematic on ethical grounds. However without such an active control group, differences between the groups might represent a Hawthorne effect, where an effect is seen simply as a result of the treated group receiving more time/attention (Snowling & Hulme, 2003). Arguably, there were available and ethical active control methods – such as parents spending an equivalent amount of time with their children helping them read (Snowling & Hulme, 2003), or perhaps an equivalent amount of time spent doing physical exercise.

- *Pre-existing literacy differences between the treatment and control groups*: it is generally considered best practice in intervention research to randomly assign participants to different conditions. Random assignment was not employed in this study, however — and despite efforts to match participants based on risk of dyslexia as assessed by the Dyslexia Screening Test — the treatment group turned out to have lower initial literacy scores than the control group (Reynolds & Nicolson, 2007). This complicates the interpretation of the results as the treatment group might be expected to improve its initial scores more than the control group simply because of statistical phenomena (Snowling & Hulme, 2003).
- *Inappropriate measures*: Singleton and Stuart (2003) are critical of the appropriateness of the literacy measures used by Reynolds et al. (being the Dyslexia Screening Test/'DST', the NFER-Nelson Group Reading Test, and the Standard Assessment Tasks/'SATs').
    - First, Singleton and Stuart argue that the DST measures are not appropriate measures of literary improvement in this kind of study. The DST is a screening test and it is not clear whether it produces the desired normal distribution (and appropriate data to this end are not provided). The subtests are arguably overly brief, can require subjective judgement with little guidance, and may in any case not be very 'pure' (see Singleton & Stuart, 2003, p. 153). Further problems identified include that three of the subtests used take different forms for different age groups (meaning children may have received different versions of the tests in the pre- and post-intervention testing), and that the measures conflate speed and accuracy – meaning an increase in test score could in fact be due to increased motivation to work faster as opposed to improved skill/accuracy.
    - Second, Singleton and Stuart note that the NFER-Nelson Group Reading Test is an odd choice (given the small number of participants) over individual reading tests. They also raise concerns over the authors' interpretation of the change between July 2000, 2001 and 2002, arguing the July 2001 result might represent a "temporary blip in a progress curve that is otherwise unexceptional".
    - Finally, Singleton and Stuart are critical of the use of SAT data. Their view is that the SATs do not relate well to other well-supported psychometric reading measures, and are "inherently unreliable because of the vague definitions that accompany the criteria for standards of attainment". They also question the way Reynolds et al. convert categorical SAT data to numerical scores, particularly for the writing scores.
- *Inappropriate statistical treatment*, even if measures are appropriate: this is explained by Snowling and Hulme (2003) who identify a number of issues with treatment of data relating to the children's reading and spelling ability. First, they

note that scores obtained from the Dyslexia Screening Test were reported as average centile scores for the two groups, which they argue is not appropriate. Ordinal measures, they argue, should not be averaged in this way because one obtains a misleading result where "differences between scores near to the mean that may not be important" are magnified and "large differences in top and bottom of the distribution" (p. 130) are reduced. Secondly, the authors' use of 22 t-tests is inappropriate — first because no correction was made for the many separate tests carried out, but second and more importantly because they cannot test the most important hypothesis: that the Dore treatment group improved differentially over time compared to the control group. It would have been better, according to Snowling and Hulme, to conduct an ANCOVA on the post-intervention raw scores for both groups using the pre-intervention raw scores as a covariate. This would have allowed the researchers to conclude that "the children in the DDAT group had made more progress in reading than the children in the untreated control group, and this difference could not be explained by uncontrolled differences in the children's reading scores before the intervention began" (pp. 131-132).

  - ***However***, this analysis was carried out as requested in a response to Snowling and Hulme's critique (Nicolson & Reynolds, 2003). They found that "[t]here was significantly greater effect for the intervention group on bead threading, reading and semantic fluency [$F(1,32) = 7.2$, $p<0.05$; $F(1,32) = 4.8$, $p<0.05$; $F(1,32) = 8.5$, $p<0.0001$, respectively]. No other sub-tests reached significance. The pattern of significant results is therefore the same as that found in our published two factor analyses of variance."

- Failure to report relevant descriptive statistics: Snowling and Hulme further argue the article's statistical failings are exacerbated by its authors' failure to include relevant descriptive statistics.
- Odd nonsense passage reading data: Singleton and Stuart (2003) draw attention to the fact that Reynolds et al. claim the treatment group showed a significant improvement on the nonsense passage reading subtest (noting this was at a somewhat dubious significance level of $p<0.1$ using a one-tailed test), but do not discuss the fact that the control group actually (also) showed a significant improvement (at the $p<0.01$ level, moreover) on the nonsense passage reading subtest. Given that children with dyslexia tend to have more difficulty with phonological decoding than other key literacy skills, this result does not lend support to the hypothesis that Dore treatment is useful for dyslexia. Singleton and Stuart argue that were it effective, one would expect to see clear improvements differences between the groups in phonological decoding skill.
- A mismatch between the data and the proposed causal explanation: Stein (2003) notes that the treatment group (who were selected for being at risk of dyslexia) had postural stability already greater than average before Dore treatment commenced. It is thus far from clear that the children's reading difficulties were the result of cerebellar abnormality (as indicated by postural instability – i.e., what Dore tries to improve). It consequently seems odd to hypothesise that causes dyslexia/poor reading and can be remediated by postural exercises. A similar point is made by Bishop (2007, p. 654), who argues that "[i]f training eye–hand co-ordination, motor skill and balance caused generalised cerebellar development, then one should find a low rate of dyslexia and ADHD in children who are good at skateboarding, gymnastics or juggling. Yet several of the celebrity endorsements of the Dore programme come from professional sports people."

Price:

As at Tuesday, 6 January 2015, the price of the Dore programme does not seem to be available on its New Zealand website. Stephenson & Wheldall (2008) report that the programme costs around AUD 5,000.

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I Fast ForWord

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What it involves:

Fast ForWord Language and Literacy Series

Created by the Scientific Learning Corporation, Fast ForWord is a computer based series with tasks in a "game" format. The programme slows and amplifies the specific hard-to-process sounds of English language (makes rapid consonant transitions longer and increases the amplitude of some transitions). This acoustically modified speech is used in tasks and adapts from slowed down to naturally fast speech based on linguistic performance (i.e. move towards more rapid and less amplified natural speech following correct responses and vice versa following incorrect responses). Tasks involve the simultaneous development of major cognitive and reading skills and are individually adaptive to keep students continuously challenged, but not too difficult so that they do not lose interest (~80% accuracy). Participants are given instant feedback on performance – correct responses are rewarded with points or auditory-visual animations and incorrect responses are indicated by an auditory cue and presentation of the correct answer.

One theory about the underlying cause of language impairments is the rapid auditory processing deficit hypothesis, which posits that children with developmental language impairments have difficulty processing the "rapid spectro-temporal characteristics of phonemes or sounds" (Gaab, Gabrieli, Deutsch, Tallal, & Temple, 2007; Tallal, 2004). This is said to consequently affect the phonological processing of language (a key skill for reading). The modified speech in the Fast ForWord exercises is designed as such so that it targets this rapid auditory processing deficit while also training other cognitive and reading skills.

<u>Fast ForWord Language Series: Language v2</u>

See http://indigolearning.co.za/pdfs/support/LanguageV2/Langyage%20V2%20Manual.pdf for more details.

- *Sky Gym:* participant identifies and remembers the order of a series of frequency-modulated sound sweeps and then indicates the pattern just heard. Targets listening accuracy and auditory sequencing
- *Moon Ranch:* a syllable is repeated (e.g. shu) and then a target syllable (e.g. chu) is presented. Participant has to identify the target syllable when the syllable changes. Targets phonological fluency and memory as well as sustained attention.
- *Robo-Dog:* listens to a target word and selects the picture that represents that word. Targets vocabulary, auditory word recognition, phonological accuracy and phonological fluency.
- *Ele-Bot*: picture that best matches spoken sentences is selected. Targets listening accuracy, English language conventions and vocabulary.

- *Space Commander*: participant is presented with rows of blocks that vary in colour, shape and is given oral instructions e.g. touch the red square and the blue circle. Targets listening accuracy and the ability to follow directions.
- *Hoop Nut:* participant listens to a target syllable and then identifies the target when it is heard in a sequence of two syllables. Targets phonological accuracy, fluency and memory.
- *Whalien Match:* participant has to identify pairs of matching words or syllables. Participant clicks a whalien character to hear the word/syllable and must rely on memory to find the matching whalien. Targets auditory word recognition, phonological memory, accuracy and fluency.

<u>Fast ForWord Language Series: Language to Reading v2</u>

See http://mygemm.com/wp-content/uploads/2010/08/LangReadv2Manual.pdf for more details.

- *Jumper Gym*: participant hears a sequence of sound of sound sweeps, has to remember and identify the sequence heard. Follows on from Sky Gym from Language v2, but more sounds need to be remembered here. Targets sequencing and working memory skills and improves auditory processing.
- *Polar Planet*: participant has to identify a pronounced target word when it is presented in a series of words (each word is presented in simultaneous oral and written form). Targets left to right eye tracking skills, working memory and requires focus/attention.
- *Tomb Trek*: participant has to identify a spoken target word when presented with a sequence of two words (each presented in simultaneous oral and written form). Targets word analysis, decoding, phonological awareness and working memory.
- *Paint Match*: participant has to match all words into pairs using the fewest clicks. Builds on Whalien Match from Language v2. Words are presented in simultaneous oral and written form. Targets working memory, organisation and focus/attention skills.
- *Cosmic Reader*: participant has to listen to a story and answer questions. Also involves following instructions. Targets listening comprehension skills and familiarity with English language conventions.

<u>Fast ForWord Literacy Series: Literacy</u>

See http://mygemm.com/wp-content/uploads/2010/08/LiteracyManual.pdf for more details.

- *Galaxy Goal*: participant listens to a series of sounds and clicks a button when the sound changes. Targets phonological fluency and memory as well as sustained attention.
- *Lunar Tunes*: amplifier with speakers is presented, with each speaker playing a syllable/word. Task is to match all syllables/words into pairs using fewest clicks. Targets auditory word recognition, phonological accuracy, fluency and memory.
- *Space Racer*: participant has to correctly identify a sequence of two sound sweeps. Targets listening accuracy, auditory processing speed and sequencing working memory.
- *Spin Master*: participant has to identify a target syllable when it is presented in a sequence of two syllables. Targets phonological fluency, accuracy and memory.

- *Stellar Stories*: participant has to listen to a story and answer questions. Task also involves following instructions. Targets listening comprehension, ability to follow directions, vocabulary and understanding of English language conventions.
- *Star Pics*: participant has to identify the picture that represents a pronounced target word. Targets vocabulary and auditory word recognition skills as well as phonological accuracy and fluency.

Fast ForWord Literacy Series: Literacy Advanced

See http://indigolearning.co.za/pdfs/support/LiteracyAdvanced/Literacy%20Advanced%20Manual.pdf for more details.

- *Sky Rider*: to complete the game in a manner that is as skilful as possible, participant needs to correctly identify sequences of sound sweeps. Targets advanced listening accuracy and auditory sequencing.
- *Laser Match*: monitors in groups of 4, 8 or 18 are displayed, each associated with a word. Participant has to match all words into pairs using the fewest clicks. Targets word analysis and phonological accuracy.
- *Meteor Ball*: participant has to identify a pronounced target word when it is presented in a series of pronounced and written words. Targets word analysis, phonological fluency, sustained attention and visual tracking (strengthens left to right reading behaviour).
- *Lunar Leap*: participant has to identify a spoken target word when it is presented in a sequence of two words (each word is presented in simultaneous spoken and written form). Targets word analysis, phonological accuracy and phonological memory.
- *Galaxy Theatre*: participant has to listen to a story and answer questions. Task also involves following instructions. Targets listening comprehension, ability to follow directions, vocabulary and understanding of English language conventions.

Fast ForWord Reading Series

This Series is generally administered following completion of the Language and Literacy Series. These are also individually adaptive and participants are given instant feedback on their performance.

Note: some of these tasks, particularly those that are part of the more advanced levels of the Series, may be beyond the scope of this audit as it targets more advanced skills and an older age group. We have mentioned them here, just in case they may be of some relevance or interest.

Fast ForWord Reading Series: Reading Readiness

See https://www.polk-fl.net/staff/teachers/reading/documents/Tools/A-1%20Resource%20Binder%20-%20FFW%20RDG%20Products/Read_Tchr_Manual/Reading_Prep/RPrep_MNL.pdf for more details.

- *Inside the Tummy*: participant "feeds" a hungry bear by dragging coloured shapes into the corresponding outlines located inside the bear's tummy. Each time the participant correctly places an object, the bear announces the shape and colour to reinforce knowledge. Targets visual attention and fine motor skills as well as hand-eye coordination

- *Hungry Tummy*: a bear asks for certain objects of various shapes, colours and sizes. Participant must correctly identify the objects and "feed" this to the bear. Targets ability to follow verbal directions, listening comprehension and working memory skills.
- *Packing Pig Goes to Work*: the participant helps Packing Pig work by listening for a spoken target letter and then clicking the matching written letter from a display of several letters. The participant is assisted through the task at first as the target letter flashes, but must then rely on sounds to identify the letters. Targets letter-name association skills, auditory working memory, visual attention and hand-eye coordination.
- *Packing Pig Has Lunch*: participant must match corresponding uppercase and lowercase letters on a grid to clear the grid. Participant can click on the letter to hear the letter's name. Targets letter-name associations for uppercase and lowercase letters, auditory working memory and visual-spatial memory.
- *Coaster*: participant hears a target consonant-vowel syllable and must select the written word containing the target consonant-vowel combination. Targets phonemic awareness and letter-sound association skills as well as an understanding of the alphabetic principle.
- *Houdini*: "Houdini the magic dog" presents four cards and the participant must select the card that presents a different first sound (but also occasionally a different last or middle sound) than the other three cards. The cards display pictures that represent the spoken words in the first stage, the picture and written word in the second stage and only the written word in third stage. Targets phonemic awareness and basic decoding skills.

<u>Fast ForWord Reading Series: Reading Level 1</u>

See https://www.polk-fl.net/staff/teachers/reading/documents/TeacherHandbook/Product%20Information/FF%20Reading%201/ManualReading1.pdf for more details.

- *Bear Bags*: participant hears a word with a target sound, then sorts "toast" with that word or picture of that word into the appropriate lunch bag (i.e. phoneme-based category). Targets phonemic awareness, understanding of the alphabetical principle and decoding skills. Also includes a speed/fluency round where participant must perform the task within a set time limit.
- *Magic Rabbit*: participant helps the magician change one word into another by choosing the correct letter from a selection of letters to spell the target word. Uses spelling and word-building to "increase sensitivity to letter-sound correspondences".
- *Flying Fish*: a target word is presented by a fishing pelican (oral and written form). Participant must click on fish with the target word from a series of fish with words displayed on them. At first, flying fish words are given in both oral and written form but are then only presented in written form. Targets decoding skills, auditory memory, visual identification of words and visual tracking (strengthen left-to-right reading patterns). Also includes a fluency round.

- *Quail Mail*: mail displayed with a picture or written word (which is also pronounced) must be sorted into the appropriate semantic and linguistic categories. Targets vocabulary and encourages flexibility during reading. Includes a fluency round.
- *Bedtime Beasties*: participants must complete a sentence by selecting the most appropriate picture, word, letter or punctuation mark. Initially, the sentence is also spoken aloud. Targets sentence comprehension and vocabulary skills.
- *Buzz Fly*: text is presented on the screen and also read aloud, with each line of text highlighted as it is being read. Participant must then answer a question about the text (which is also read aloud) by selecting the picture that best answers the question. Targets listening comprehension and working memory.

Fast ForWord Reading Series: Reading Level 2

See http://mygemm.com/wp-content/uploads/2010/08/Read2Manual.pdf for more details.

- *Bear Bugs: More Lunch*: similar to *Bear Bags* from Level 1. Also includes a fluency round.
- *Magic Bird*: similar to *Magic Rabbit* from Level 1.
- *Fish Frenzy*: similar to *Flying Fish* from Level 1. Includes a fluency round.
- *Leaping Lizards*: similar to *Bedtime Beasties* from Level 1.
- *Ant Antics*: students select the sentence from a selection of four that best describes a picture. Targets critical reading skills and sentence comprehension.
- *Dog Bone*: similar to *Buzz Fly* from Level 1. Instead of choosing a picture, as in *Buzz Fly*, the participant must select the written response that best answers the question.

Fast ForWord Reading Series: Reading Level 3

See https://www.polk-fl.net/staff/teachers/reading/documents/TeacherHandbook/Product%20Information/FF%20Reading%203/ManualReading3.pdf for more details.

- *Scrap Cat:* participant must sort target word into appropriate category. Categorisation targets decoding skills, automatic word recognition, semantic understanding, syntax, phonology, morphology and conceptual relationships.
- *Canine Crew:* participant must match pavers with words using the fewest number of clicks. Task may be to match synonyms, antonyms, rhymes or homophones. Targets decoding skills, vocabulary, automatic word recognition, semantic understanding, phonology and conceptual relationships.
- *Chicken Dog:* an incomplete target word is presented in written form, and is then pronounced. Participant must select the correct missing letter(s) to complete the word. Targets spelling, letter-sound correspondences and phonemic awareness.
- *Twisted Pictures:* participant must select the sentence that best describes a picture. Targets sentence comprehension, syntax, working memory, logical reasoning and vocabulary.
- *Book Monkeys:* participant reads a paragraph and is then asked a question relating to the paragraph. The participant must select the most appropriate answer from a selection of written answers. Targets paragraph comprehension, understanding of cause and effect, ability to make inferences, working memory and vocabulary.

- *Hog Hat Zone:* participant must select the most appropriate words to fill in the blanks in a paragraph of text. Targets paragraph comprehension, understanding of pronouns, auxiliary verbs, prefixes, suffixes, word-sentence links and helps build a foundation for vocabulary growth.

Fast ForWord Reading Series: Reading Level 4

See http://mygemm.com/wp-content/uploads/2010/08/Read4Manual.pdf for more details.

- *Hoof Beat:* a word or instruction is presented and the participant must select the response that best matches the word/instruction. Targets decoding skills, vocabulary, sentence comprehension, sematic understanding, syntax, phonology, morphology and orthography. Also introduces participant to homophones and homographs.
- *Jitterbug Jukebox:* participant hears a word pronounced and must click the available letters to spell the word out. If an incorrect letter is selected, the trial ends and the correct word is displayed. Targets spelling, letter-sound correspondences, phonological awareness and vocabulary.
- *Stinky Bill's Billboard:* participant must select the word that best completes a sentence. Targets sentence comprehension and decoding. Also reinforces the links between word meanings and sentence structure.
- *Lulu's Laundry Line:* a paragraph is displayed, with missing words and punctuation. For each blank, participant must select the word/punctuation mark from a selection of two or four choices that is most appropriate. Targets the development of capitalisation and punctuation skills, an understanding of the link between words and sentences and an understanding of sentence and paragraph comprehension.
- *Book Monkeys: Book Two:* more advanced version of *Book Monkeys* from Level 3.
- *Goat Quotes:* participant must select a sentence that best paraphrases a headline. Targets (fairly advanced) sentence and paragraph comprehension, working memory, logical reasoning, decoding, syntax and vocabulary skills.

Fast ForWord Reading Series: Reading Level 5

See http://mygemm.com/wp-content/uploads/2010/08/Read5Manual.pdf for more details.

- *Wood Words:* participant must sort a target word (written or pronounced) into the appropriate phoneme or spelling-based categories. Targets spelling accuracy and fluency, decoding and phonemic analysis. Includes a fluency round.
- *Gator Jam:* participant has to complete an analogy by identifying the missing word(s). Participant must then read a completed analogy and sort it into the type of analogical relationship it demonstrates. Targets vocabulary skills, critical thinking and abstract reasoning.
- *Toad Loader:* participant must select the appropriate word or phrase to construct a sentence that best describes a picture. Targets accuracy and fluency in recognising and constructing sentences.
- *Lana's Lane:* participant reads a passage of text, which is followed by comprehension questions that involve either graphically or textually organising information from the passage using a range of different comprehension strategies. Strategies for graphically organising information included building a diagram and filling in a graphic organiser. Strategies for textually organising information include

choosing or building a summary. Targets reading comprehension and the development of comprehension strategies.

- *Quack Splash:* this is quite an advanced task. Participant must select the correct text to complete a paragraph. Participants must then correctly order sentences to build paragraphs. Next, participants must correctly order paragraphs to build pages of a chapter. Finally, participants must answer comprehension questions about the chapter. Targets the construction and organisation of fiction and nonfiction passages, and the understanding and use of figurative language.

Prescribed protocols for all Fast ForWord Series: three days a week for 30 or 50 mins; five days a week for 30, 40, 50 or 90 mins.

What claims does the company make / what does the programme target?

Fast ForWord Language and Literacy Series target the development of listening accuracy, phonological awareness and language structures. The Language Series is aimed at primary school-aged children while the Literacy Series is aimed at intermediate to high school-aged children. The website claims that children using either the Language or Literacy Series can expect a reading gain of one to two grade levels, on average, in 8 to 12 weeks. The website also claims that tasks bring about physical changes in the brain that result in "enduring gains".

Specific skills targeted by each of the tasks are described above, but in general focus on language (e.g. listening accuracy, phonological awareness, language structures) and reading-related skills (e.g. letter/word recognition, letter-sound associations, decoding, vocabulary, comprehension) as well as cognitive abilities (e.g. working memory, attention, processing and sequencing).

Evidence for efficacy:

The vast majority of studies investigating the Fast ForWord programme have focused on the ***precursor*** to Language v2. This is true for studies showing evidence for and against the programme's effectiveness. Consequently, the efficacy of the current redesigned Language Series is yet to be determined. There is also a dearth of studies looking at the Literacy and Reading Series.

Behavioural Studies:

<u>*Merzenich et al. (1996); Tallal et al. (1996):*</u>

These articles, authored by the founders of the Scientific Learning Corporation and creators of Fast ForWord, describe the results of pilot studies conducted on prototypes of Fast ForWord (FFW) Language exercises. In the first study, seven 5 to 9 year olds with speech language impairment (SLI) underwent FFW Language training and also completed several clinician-administered intervention exercises as well as 1 to 2 hours of homework daily, 5 days/week for 4 weeks. The study found that children showed significant improvement over the 4 week period on the FFW Language exercises. Children also made significant gains on speech discrimination, language processing and grammatical comprehension measures, and improved on the Tallal Repetition test (test of temporal processing ability).

In the second study, 22 children with SLI (also 5 to 9 years) were divided into two groups. Both groups received equivalent language training with a clinician and completed homework daily. One group (Group 1) completed several prototype FFW Language exercises. Group 1 also listened to acoustically modified speech in both their daily clinician-directed intervention sessions and their homework (involved listening to stories). Group 2 was exposed to normal speech and played video games rather than the FFW exercises. The study found that children in Group 1 showed greater improvements on measures of temporal processing, speech discrimination and grammatical comprehension than children in Group 2. Both Studies 1 and 2 also found that improvement on the Tallal Repetition Task was significantly correlated with post training language processing ability.

<u>Limitations:</u> not an independent study as it was conducted by the creators of FFW; we cannot be sure whether the results are specific to the FFW training, the clinician-directed intervention sessions (and homework) or a combination of the two; these studies used prototype versions, results may be different with current FFW Language programme; sample size, particularly for the first study.

<u>*Rogowsky, Papamichalis, Villa, Heim, & Tallal (2013):*</u>

To our knowledge, this is the only peer-reviewed article that has reviewed the efficacy of both the FFW Literacy and FFW Reading programmes. 25 college students with poor writing skills (some were native English speakers, some spoke English as a second language [ESL]) underwent FFW Literacy and Reading (Levels 3-5) training for approximately 50 mins/day, 4-5 days/week for 11 weeks. Participants completed the Literacy exercises before proceeding to the Reading tasks. 28 students were also selected from the general college population to form a comparison group, but did not undergo FFW training. Reading and writing skills were assessed before and after the training period.

Prior to undergoing the intervention, the training group showed average reading skills though this was significantly below that of the comparison group. Following intervention, the training group made significant gains on reading whereas no change was observed for the comparison group. However subsequent analyses revealed that only the native English speakers significantly improved their reading abilities following training.

The training group, who exhibited below average writing skills pre-training, significantly improved their writing skills following training. This gain meant that the training group's writing scores significantly exceeded that of the comparison group following intervention. Subsequent analyses on the training group revealed that while the ESL students showed lower writing skills that the native English speakers, both subgroups significantly improved on writing following training.

<u>Limitations:</u> there was no no-treatment group with low writing skills; no alternative treatment group; conflict of interest as Paula Tallal, one of the creators of the FFW programme, is a co-author of the study.

Neuroimaging/Neurophysiological Studies:

<u>*Temple et al. (2003):*</u>

Twenty 8 to 12 year olds with dyslexia underwent training on an earlier version of FFW Language (100 min/day, 5 days/week for average of 27.9 days). Twelve typically developing control children also participated in the study, but did not undergo FFW training. All participants were assessed on measures of reading, language and phonological processing before and after the training period. Participants also completed tasks in the fMRI scanner (specifically a phonological rhyming task with letters and nonphonological matching task with letters – comparison of the two tasks will indicate brain activity during phonological processing).

The study found that children with dyslexia significantly improved on measures of reading (into the normal range), oral language ability and rapid naming (a phonological processing measure) following FFW Language remediation. fMRI results indicated that there were two regions underactive in dyslexics (but active in normal reading children) prior to remediation that were ameliorated following remediation: the left temporo-parietal cortex (this was only partially ameliorated as the region was near but not overlapping the region activated in the typically developing children) and left inferior frontal gyrus. The dyslexic children also showed increases in brain areas following remediation that were not active in normal-reading children, of which the most noteworthy are:

- right inferior, middle and superior frontal gyri; right middle temporal gyrus (authors suggest that this may be compensatory activation, similar to activation that seen in patients suffering from brain injury during recovery of function);
- bilateral cingulate gyrus (this may be due to FFW's concurrent training of attention);
- left hippocampal gyrus (possibly due to FFW's training of working memory).

Authors also note that there was a positive correlation between increases in oral language ability and activation in the left temporo-parietal cortex. There was also a significant correlation between increased activation in the right inferior frontal gyrus and a measure of phonological processing (Comprehensive Test of Phonological Processing [CTOPP] Blending Words).

Limitations: the study used an earlier version of FFW Language; there was no no-treatment dyslexic control group; no alternative treatment group; several of the FFW creators were co-authors of the article.

Gaab et al., 2007:

22 children with dyslexia underwent training using an earlier version of FFW Language (100 mins/day, 5 days/week for 8 weeks). 22 typically-reading children were also recruited but did not participate in the FFW exercises. All subjects were assessed on language, phonological awareness and reading measures before and after the training period and also completed a rapid auditory processing task while in the fMRI scanner. This fMRI task involved listening to non-linguistic acoustic stimuli with either rapid or slow transitions, which were designed to "mimic the spectro-temporal structure of consonant-vowel-consonant speech syllables".

Prior to remediation, there were significant differences between dyslexic and control children on all measures. Following remediation, while there were significant improvements on almost all behavioural measures for the dyslexic children, children's performance was equivalent to that of the typical readers only for measures of phonological awareness and listening comprehension. fMRI results indicated that while typical readers showed widespread activation to rapid (vs slow) auditory transition, the dyslexic group only showed activation in the left middle temporal gyrus prior to remediation. However, following FFW Language remediation, the dyslexic children showed increased activation in several regions that were part of the network activated in typical readers. These regions included: bilateral insula; left operculum; right inferior frontal sulcus; left superior frontal regions; right precuneus; cingulate gyrus; bilateral thalamic regions; left prefrontal regions.

Limitations: an earlier version of FFW Language was used; there was no no-treatment dyslexic control group; no alternative treatment group; Paula Tallal was one of the co-authors.

Stevens, Fanning, Coch, Sanders, & Neville (2008):

This particular study was interested in looking at whether training with an earlier version of FFW Language influenced mechanisms of selective auditory attention. Twenty 6 to 8 year olds received 6 weeks of FFW Language training (8 with SLI, 12 typically developing). 13 additional typically developing children were recruited but did not receive any training. Participants were assessed on measures of receptive and expressive language before and after the training period. The children also took part in an ERP attention paradigm, and their ERPs for attended and ignored stimuli were compared.

For behavioural measures, both the SLI and typically developing FFW groups showed significant increases in receptive language following training, while there was no change in receptive language measures for the no treatment group. ERP results prior to remediation indicated that both typically developing groups exhibited a larger positive response to attended than unattended stimuli approximately 100-200ms post-stimulus presentation. In contrast, the SLI children showed a similar response to both attended and unattended probes within the same time window. However, following training, results indicated that there was a greater difference in the ERP response for attended and unattended stimuli than at the pre-training assessment for both the SLI and typically developing FFW groups. Additionally, the FFW group combined showed a significantly larger pre to post training change in this effect than the no treatment group. Further analyses revealed that this change was due to signal enhancement, as there was an increase in the neural response for attended stimuli, but no change in the response for unattended stimuli.

Limitations: an earlier version of FFW Language is used; no behavioural measures of attention included; no no-treatment SLI control group; no alternative treatment group; a token economy system was in place to motivate children, even though the FFW programme is designed with motivation measures within the task (e.g. points for correct answers). This would have played a role in maintaining the children's attention and engagement and may have consequently confounded results. It is worth questioning whether the FFW Language programme alone would have produced similar ERP results.

The vast majority of studies investigating the Fast ForWord programme have focused on the precursor to Language v2. This is true for studies showing evidence for and against the programme's effectiveness. Consequently, the efficacy of the current redesigned Language Series is yet to be determined. There is also a dearth of studies looking at the Literacy and Reading Series.

Heim, Keil, Choudhury, Thomas Friedman, & Benasich (2013):

This study investigated the change in early oscillatory responses in the auditory cortex following FFW Language training. 21 primary school children with language-learning impairment (LLI) underwent FFW training for an average of 32 days. Tests on language and reading ability were conducted before and after training, as well as EEG recordings while participants listened to fast-rate tone doublets. 12 typically developing children were also tested, but did not participate in the FFW Language training.

Behaviourally, LLI children showed improvements in measures of language (receptive, expressive and core composite) only following FFW training. Relative to the typically developing children, the LLI group showed reduced amplitude and phase-locking of early (45 – 75 ms) gamma band oscillations in response to the second tone in the doublet prior to remediation. Following training, the amplitude for both the LLI and typically developing groups was equally strong for both tones, though participants still showed attenuated phase-locking. Additionally, receptive language scores were predicted by the phase-lock index (a measure of phase-stability) gains for the second tone, while improvements on receptive language abilities were predicted by phase-lock index gains for the first tone.

The authors suggest that these "gamma band responses" are a potential marker of deficits in rapid auditory processing. However the authors also noted that gamma band responses have been linked to memory and attention. Given that some of the studies above (Stevens et al., 2008; Temple et al., 2003) indicate that FFW Language training improves other cognitive abilities, particularly attention, we cannot be sure that these responses are indicative of rapid auditory processing deficits and not deficits in other core cognitive abilities commonly linked to developmental language impairments.

<u>Limitations:</u> an earlier version of FFW Language was used; sample size; no control group; no alternative treatment group.

Evidence against efficacy:

Studies arguing against the efficacy of the FFW programme generally take on a comparative approach. While most of these studies show that there are benefits to the FFW intervention, these benefits are not greater than that of other intervention programmes with non-modified speech. Thus, the results of these studies suggest that training specifically with acoustically modified speech is not necessary for the remediation of language impairments. The efficacy of the Literacy and Reading Series relative to alternative interventions is yet to be determined.

Behavioural Studies:

<u>*Hook, Macaruso, & Jones (2001):*</u>

Hook et al. investigated the efficacy of the FFW Language programme on the language and reading abilities of 7 to 12 year olds with reading difficulties, both in the short term (relative to the Orton-Gillingham intervention) and in the long term (relative to a longitudinal control group). Children in the FFW group (n = 11) completed 5 of 7 FFW Language exercises (earlier version) for 100 mins overall, 5 days a week for 2 months, while children in the Orton-Gillingham (OG) group (n = 9) received a one-to-one intervention method for one hour a day, 5 days a week for 5 months. The longitudinal control (LC) group (n = 11) had similar levels of reading difficulties to the FFW group and received "multisensory structured language instruction over a period of 2 academic years". Behavioural measures were collected prior to training for the FFW and OG groups only, post training for all 3 groups and at the end of the first and second academic year for the FFW and LC groups.

Results indicated that while the FFW group did improve on phonemic awareness immediately following training, this improvement was not greater than that of the less intensive OG group. Additionally, the OG group made significant gains on the Word Attack component of the Woodcock Reading Mastery Test – Revised, whereas the FFW group made no gains on reading-related measures. The FFW group did show short-term gains on the speaking and syntax components of spoken language, but as this measure was not assessed in the OG group, it is unknown whether this improvement would have been greater than that of the OG group. Additionally, these improvements were not maintained in the long term. Children in both the FFW and LC groups did not differ significantly on any measure over the course of two years; both groups significantly improved on phonemic awareness and reading measures (these gains were over and above that of age-related improvements).

<u>Limitations:</u> an earlier version of FFW Language was used; participant recruitment differed for the OG and FFW groups. Children in the OG were enrolled in a summer school for children with reading difficulties, whereas the FFW participants were those who responded to flyers advertising the study. While the groups did not significantly differ on IQ, age, phonological awareness and reading abilities, it is possible that the summer school may have provided the OG children with a more structured and well-controlled environment than the FFW group,

which may have contributed to the efficacy of the intervention. Although children in the study did have reading difficulties, they had average VIQ and receptive language skills. Results may have been different for children with more extensive language problems.

Pokorni, Worthington, & Jamison (2004):

Sixty 7.5 to 9 year olds with language and reading difficulties were randomly assigned to 1 of 3 intervention programmes: FFW Language, Earobics (Step 2) and LiPS. All participants received three 1 hour interventions daily over the course of a 20 day summer programme and were assessed on phonemic awareness, language and reading abilities before and after the intervention period.

The Earobics and LiPS groups made significant gains from pre-intervention to post-intervention on measures of phonemic awareness only. There were no significant improvements for the FFW group. Comparing interventions, children in the LiPS programme made significantly greater gains on the Blending Phonemes measure of Phonemic Awareness relative to the FFW and Earobics groups.

Limitations: standard protocol was not used for the implementation of FFW Language. The intervention period was shorter, with more intensive daily training. This may have affected children's motivation and progression on the programme, and likely explains why this group did not improve on any of the behavioural measures. An earlier version of FFW Language was used. The sample was heterogeneous, with highly variable pre-intervention results for language measures.

Gillam et al. (2008):

A randomised controlled trial, where 216 children with language impairments (6 to 9 years old) were randomly assigned to either:

- FFW Language;
- computer-assisted language intervention (CALI): also computer game-based, and targets similar skills as the FFW Language programme but speech stimuli are not acoustically modified;
- individualised language intervention (ILI): based on a social interactionist perspective, where individualised therapy is provided by a speech-language pathologist;
- an academic enrichment (AE) intervention: although these computer games did involve vocabulary, instructions and visual and verbal input, they were focused on maths, social studies and science and thus were not designed to specifically improve language and reading-related skills.

All children received 100 mins of treatment, 5 days/week for 6 weeks, and were tested on a battery of language, literacy and auditory processing measures before remediation and immediately, 3 months and 6 months post-remediation.

Children in all four groups generally made significant gains on language measures and sentence comprehension immediately after the intervention and at the 3 month and 6 month follow ups. FFW, CALI and ILI groups made significantly greater gains than the AE group on the blending words measure of phonological awareness immediately following remediation. There were no significant differences between groups at the 3 month follow up, but both the CALI and FFW children outperformed the ILI and AE groups on blending words at 6 months (suggesting that training games with modified speech are not any more effective than training games with regular speech). Backwards masking was used to test children's temporal processing skills, with results indicating that all 4 groups made equally significant improvements at all post-remediation assessments.

Limitations: the study uses an earlier version of FFW Language.

Loeb, Gillam, Hoffman, Brandel, & Marquis (2009):

This study reanalysed the data of a subgroup of participants (*n* = 103) from the Gillam et al. (2008) study, specifically children who had both specific language impairment and poor reading abilities. This study also just focused on measures of reading and phonemic awareness, and only looked at gains from pre-intervention to immediately post-intervention and from post-intervention to the 6 month follow up.

FFW Language, CALI and ILI groups all made significantly greater gains than the AE group from pre-intervention to immediately post-intervention on the blending sounds measure of phonemic awareness, but these gains did not significantly differ between the three intervention groups. There were no significant long-term gains and no short term or long term reading improvements for any of the intervention groups. These findings also seem to suggest that the acoustically modified speech in the FFW Language programme is not essential for the improvement of phonemic awareness skills.

Limitations: as a subgroup of the original sample was used, the design was quasi-experimental rather than a RCT; an earlier version of FFW Language was used.

Price:

According to the *What Works Clearinghouse* website (http://ies.ed.gov/ncee/wwc/reports/adolescent_literacy/fastfw/info.asp), a single license for the Fast ForWord Language Series is US$900, with discounts available for multiple licenses. For the Fast ForWord Reading Series, single licenses cost US$500, with no quantity discount.

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J Lexia Reading

Website / for more information see:

http://www.lexialearning.co.nz/

http://lexialearning.com/product/core5

What it involves:

The Lexia programmes, created by Lexia Learning Systems, are comprised of several computerised activities. Each activity in the programme may have one or several different types of tasks, with each type involving a number of units. These units cover a particular sub-skill of the main skills targeted by the activity and will increase in difficulty as the learner progresses. The learner can only progress to the next unit if they master the skill within the current unit.

The programme also provides immediate feedback, and includes instruction and scaffolding when necessary. Scaffolding can generally involve simplifying the task by reducing choices, adjusting the complexity of language, altering the presentation and visual components of the task or providing embedded support. Additional instruction and scaffolding are presented when necessary, though if students require this more than once within a unit, the teacher is notified that the student is struggling and requires further assistance.

Lexia has an embedded Assessment Without Testing component, which provides educators with norm-referenced performance data that has been obtained without administering a formal test. Based on the student’s skill level and progression, the system prescribes instructional intensity to improve performance and provides detailed reports on the student’s skill deficits as well as recommended targeted instructional materials to improve skill development. The system is also able to predict the student’s chance of reaching an end of year benchmark.

Activities for each Level of Lexia Reading Programmes are described below. These have been obtained from Lexia Reading teacher manuals (Lexia Reading Systems, 2012, 2013).

Lexia Reading Core5:

Lexia Reading Core5 replaces and expands on the earlier Lexia Reading programme offered by Lexia Learning Systems. The activities are based on the United States' Common Core State Standards. The programme covers 6 areas of reading: phonological awareness, phonics, structural analysis, automaticity/fluency, vocabulary and comprehension. Specifically, the programme focuses on foundational skills to develop automaticity and fluency, listening and reading comprehension with complex text, and academic and domain-specific vocabulary to improve comprehension.

Lexia Reading Core5 allows students to independently develop reading skills in a structured and sequential manner. The learning path of each student is personalised and adaptive.

<u>Level 1: A Picnic in the Woods</u>

This focuses on pre-kindergarten skills.

- *Rhyming*: Two pictures are displayed under a target picture, and each picture is highlighted and named. The learner must select the picture that rhymes with the target image. Targets phonological awareness skills, specifically an awareness of rhyme patterns in spoken language.
- *Letter matching*: There are two tasks within this activity. In the first task, the learner must select the two identical letters from a selection of four. In the second task, the learner must select the lowercase letter that corresponds to the target uppercase letter. This activity is under the phonics component and targets the recognition of upper- and lower-case letters.
- *Categorising Pictures*: The learner must sort a set of objects into two or three categories. Targets vocabulary by developing knowledge of word relationships.
- *Nursery Rhymes*: a nursery rhyme is read along with images. Following this, the first part of the nursery rhyme is presented along with three pictures, and the learner must select the picture that best matches that part. The learner then progresses to the next part of the nursery rhyme, and the process continues until the rhyme is completed. This targets comprehension as it focuses on developing an understanding of narrative story structure.

<u>Level 2: A Day at the Beach</u>

This focuses on early kindergarten skills.

- *Blending and Segmenting 1*: in the blending tasks, three pictures are displayed and a target word named with a pause between each syllable. The learner must select the picture that represents the target word. For the segmenting task, one picture is displayed and named with no pauses. The learner must drag down a token for each syllable in the word. As each token is dragged down, the programme dictates the syllable. Targets phonological awareness, specifically an awareness of syllables in words.
- *Beginning Sounds*: in the matching task, three pictures are highlighted and named. The learner must select the two pictures with the same initial sound. With the identifying task, three pictures are highlighted and named and a target sound is then named. The learner must select the picture that begins with the target sound. Targets phonological awareness.
- *Letter Names*: in the letter recognition task, a target letter is named and displayed along with six or seven other letters. The learner must then select the letter from an alphabet arc. In the alphabetising task, six letters are displayed out of alphabetical

order and the learner must organise them in order. With this task, the alphabet arc is displayed initially but then disappears after the learner's first response. This activity falls under the phonics component and targets letter recognition and sequencing.

- *Spatial Concepts*: the receptive task involves selecting a subject in an image in relation to objects. In the expressive task, the learner must place one or two shapes in relation to an object. This task falls under the vocabulary component and targets an awareness of spatial concepts.
- *Picturing Stories 1*: a story is read in three parts. After each part, the learner is presented with three pictures and must choose the picture that best matches that part. Targets comprehension, specifically an understanding of narrative story structure.

<u>Level 3: A Snow Day in the City</u>

This level focuses on kindergarten skills.

- *Blending and Segmenting 2*: this is similar to *Blending and Segmenting 1* from Level 2. Targets phonological awareness, specifically the blending of phones and onset/rimes, as well as the segmenting of phonemes.
- *Consonant Sounds*: the letter to picture matching task involves selecting the letter from a possibility of three that matches the target picture (the picture is also named). This process is reversed in the picture to letter matching task. In the consonant discrimination task, paired letters with similar sounds (e.g. d and t) are presented with five pictures that begin with one of the two letters. A student selects a picture, which is then named, and must sort it based on the first sound of its name. Targets phonics, specifically knowledge of letter-sound correspondences for beginning consonants and discrimination between similar sounding consonants.
- *Sight Words 1*: in the recognition task, the learner must select the target word. Foils are presented – these include two close spelling of the target word and another sight word. In the construction task, the learner hears a target word and must organise letters for the word, which are out of order, into the correct order. In the phrases task, a picture and an incomplete phrase are displayed. The learner hears the phrase and must then select the word (from three choices) that completes the phrase. In the automaticity task, words move on the screen and the learner must select target sight words from four choices. Targets fluency, specifically instant recognition of regular and irregular high-frequency sight words.
- *Advanced Descriptors*: four pictures are shown on screen. The learner hears a difficult word that describes three of the pictures and must select the picture that the word does not describe. This targets vocabulary knowledge for unfamiliar, high-level words through deductive reasoning.
- *Picturing Stories 2*: this task is similar to *Pictures Stories 1* from Level 2.

<u>Level 4: The Amazon Rainforest</u>

This focuses on Year 1 skills.

- *Ending Sounds*: in the recognition task, the learner hears a target sound and the names of three pictures. They must select the picture that ends with the target sound. In the word completion task, a partial consonant-vowel-consonant (CVC) word is displayed and named. The learner must select the letter from three choices that completes the word. Targets phonological awareness, specifically letter-sound correspondences for vowels.

- *Short Vowel Sounds*: in the letter to picture matching task, a short vowel is introduced in a letter morph with a target word. Two pictures are displayed and named, and the learner must select the picture that begins with the target short vowel sound. In the picture to letter matching task, this procedure is reversed. Targets phonics.
- *Beginning Sounds & Letters*: a partial word is displayed and named. The learner must select the letter (from three or four choices) that completes the word. Targets phonics, specifically letter-sound correspondences for beginning consonants in words.
- *Combining Adjectives*: the learner hears two adjectives and must select the picture (from a selection) that is best described by the adjectives. Targets vocabulary, specifically an understanding of adjectives as they relate to nouns.
- *Sequencing Stories 1*: the learner hears a story and must sort images of the story into the correct order. Targets comprehension, specifically an understanding of narrative structure and story sequence.

<u>Level 5: The Scottish Cliffs</u>

This level focuses on Year 1 skills.

- *Simple Word Chains*: a CVC word is shown on screen below four letters. The learner must replace the word on screen with a spoken word by dragging one of the four letters to the appropriate part of the displayed word. Targets phonics, specifically sound manipulation skills and letter-sound knowledge.
- *Medial Vowels*: a CVC word is spoken and the learner must select the vowel heard from between two to five choices. Targets phonics.
- *Picture-Word Match 1*: in the picture to word matching task, five pictures are displayed along with one CVC word. The learner must select the picture that matches the word. The opposite occurs with the word to picture matching task. This activity falls under the phonics component, and targets the automatic recognition of CVC words and word-level comprehension skills.
- *Sight Words 2*: this is similar to the *Sight Words 1* activity from Level 3.
- *Sequencing Stories 2*: this is similar to the *Sequencing Stories 1* activity from Level 4. However, in addition to sorting after the images into sequential order, the learner must also choose the main idea form four scenes. Targets comprehension.

<u>Level 6: A Day in Paris</u>

This targets early Year 2 Skills.

- *Building Words*: in the word comprehension task, the learner hears a word and must drag down letters to spell the word. In the long and short vowel task, the learner must sort pictures into either the short vowel sound column or the long vowel sound column. Targets phonics, specifically segmenting skills and letter-sound knowledge.
- *Consonant Digraphs*: in the digraph to picture matching task, the learner must select the word that matches the picture. Foils include two words that closely match the spelling of the target word as well as another sight word. In the word completion task, three digraphs are presented above an incomplete word. The

learner hears a target word and must select the appropriate diagraph that completes the target word. Targets phonics, specifically letter-sound knowledge for common consonant digraphs.

- *Sight Words 3*: This is similar to the *Sight Words* activities from previous levels.
- *Categorising Words 1*: in the categorising task, the learner must sort six CVC words into one of two categories (categories can be things like animals, actions, living things, outside, kitchen and inside concepts). In the associations task, a target word is displayed along with three other CVC words. The learner must select the word that best associates with the target word. This activity falls under the vocabulary component, and targets an understanding of word relationships and decoding.
- *Picture-Phrase Match*: In the one phrase task the learner sees three pictures above a phrase and must select the picture that best matches the phrase. The opposite is done in the three phrases task. In the questions task, a picture is shown along with a "yes" or "no" question about the image, which the learner must answer. Targets comprehension.

<u>Level 7: The African Serengeti</u>

This level focuses on beginning to middle Year 2 skills.

- *Reversible Letters* (b, d, p): in the visual sort task, the learner must sort b, d and p letters into their appropriate boxes. In the auditory sort task, the learner hears a word with b, d or p and must select which of the three boxes the word belongs to. In the construction task, the learner must select b, d or p to complete an incomplete word that was named. Targets phonics, specifically the instant recall of letter-sound correspondences for letters that are often confused.
- *Silent E Recognition*: in the visual sort task, the learner must sort short vowel and long (silent e) vowel words. In the long and short recognition task, a word is named and the learner must select whether it is a short or long (silent e) vowel word. In the auditory sort task, a word is named and the learner must categorise it as a short or long (silent e) vowel word. In the word recognition task, the learner must select a named word from a choice of six short and long (silent e) vowel words. Targets phonics, specifically the knowledge that silent e marks long vowel sounds.
- *Contractions & Word Families*: in the contraction task, the learner has to choose the words that form a named contraction. In the visual recognition task, the learner has to select the named contraction from a choice of six contractions. In the word scramble task, the learner must find a spoken target word in a word scramble. In the construction task, the learner must arrange four or five letters to spell a named word. This task falls under the phonics label and targets knowledge of common contractions, as well as the identification and construction of irregular words that contain common word family patterns.
- *Picture-Word Match 2*: this is similar to the *Picture-Word Match 1* activity from Level 5.
- *Sentence Comprehension 1*: the learner selects the correct word from a choice of three to complete a sentence. Targets comprehension.

<u>Level 8: The South Pole</u>

Focuses on middle to end Year 2 skills.

- *Silent E Construction*: the learner has to spell a named word by choosing a vowel sound and also determining whether the word needs a silent e. This activity falls under the phonics component of the programme, and targets learners' ability to apply the silent e pattern to long vowel words.
- *Long Vowel Teams*: in the single word construction task, an incomplete word is shown and named. The learner has to select the vowel team (from three or four choices) that completes the word. In the construction with riddle task, an incomplete word is shown and a phrase containing the word is read. The learner has to select the vowel team (from a choice of three or four teams) that completes the word. In the sentence completion task, the learner has to select a vowel team from a choice of three that completes a sentence. Targets phonics, specifically letter-sound knowledge for long vowel team patterns.
- *Two Syllable Words*: in the visual sort task, the learner has to sort word parts into two or three boxes based on syllable type. In the single word construction task, a word is displayed and the learner has to drag word parts into the appropriate box to spell out the word. In the sentence completion task, the learner has to choose one of three words to complete an incomplete sentence. Targets phonics, specifically the ability to identify open, closed and silent e syllables and combine syllables to form two syllable words.
- *Multiple Meaning Words 1*: three boxes, each with words that can have multiple meanings (e.g. pen) are displayed. The learner has to sort six pictures, each corresponding to one of the three words, into the appropriate box. Targets vocabulary.
- *Sentence Comprehension 2*: three incomplete sentences are presented below five words, and the learner must select the appropriate word to complete each sentence. The individual must then answer questions about the sentences. Targets comprehension, specifically the ability to read and understand short narratives and answer detailed questions.

<u>Level 9: The Egyptian Desert</u>

This level focuses on end of Year 2 skills.

- *Vowel Combinations:* in the word construction task, the learner has to complete an incomplete word by selecting the appropriate vowel combination (from a choice of three). In the auditory recognition task, the learner has to select a named target word from a visual display of six words. In the sentence completion task, a sentence with an incomplete word is displayed and the learner must select the vowel combination (from three choices) that completes the word. This targets phonics, specifically letter-sound knowledge for complex vowel combinations.
- *R-Controlled Vowels:* this is similar to tasks in vowel combinations, but focuses on r-vowel pairs instead.
- *Sight Words 4:* this is similar to *Sight Words* activities from earlier levels.
- *Categorising Words 2:* this is similar to *Categorising Words 1* from Level 5, but includes more complex words and more choices in the associations task.
- *Sequencing Sentences:* between three to five sentences are displayed, and the learner has to sort sentences into the correct order to tell a story. Questions are then displayed, which focus on what the story was about and factual recollection.

Each question is presented with a choice of three answers. This targets comprehension.

Level 10: An English Garden

This level focuses on beginning Year 3 skills.

- *Advanced Word Chains:* the learner has to change one word into another by swapping or adding one letter or sound from four letter choices, or deleting a letter or sound using a delete option. This targets phonics, specifically the ability to manipulate phonemes in words to create new words.
- *Multi-Syllable Words:* in the visual sort task, the learner has to sort ten syllables into two or three boxes, depending on syllable type. In the single word construction task, the learner hears a two syllable word, and must construct the word from a selection of eight syllables. In the sentence construction task, the student reads a sentence that has half a word missing, and must complete the word from a choice of six possibilities. This targets phonics.
- *Simple Suffixes:* in the visual sort task, the learner has to sort words into the appropriate box, based on their endings. In the auditory recognition task, the student hears a word and must click the box (from three or four possibilities) that has the correct suffix. In the sentence completion task, the learner must select the suffix from a choice of three to complete a sentence with half the word missing. This targets structural analysis by focusing on knowledge of common suffixes and sn awareness of the morphological structure of words.
- *Sight Words 5:* this is similar to *Sight Words* activities from earlier levels. However, for the recognition task in this activity, the learner must highlight a spoken target word from a word grid puzzle.
- *Building Sentences:* this is similar to the *Sequencing Sentences* activity from Level 9. However, instead of sorting sentences into the correct order, the learner has to sort words into the correct order to form a sentence before answering questions about the sentence. This targets comprehension through an awareness of sequence structure.

Level 11: The Swiss Alps

This focuses on middle Year 3 skills.

- *Hard and Soft C & G:* in the auditory discrimination task, the learner hears a word and must sort it based on whether it has a hard or soft sound. In the visual sort task, the learner sorts ten words into boxes, depending on whether it has a hard or soft sound. In the word recognition task, the learner must select the word they hear from a choice of six words. This activity falls under the phonics component, and targets knowledge of spelling patterns that correspond to the hard and soft “c” and “g”.
- *Syllable Division:* in the vowel identification task, the learner hears a word and must highlight the word in a puzzle. In the syllable division task, the individual hears a target sight word, and must organise letters of the word, which are out of order, into the correct order. This falls under the phonics component, and targets and understanding of rules for dividing multi-syllable words.
- *Spelling Rules 1:* in the spelling dictated words task, the learner has to type a spoken word. In the sentence completion task, the learner hears a sentence, which

is also displayed but with a word missing. They must then type in the missing word. This activity falls under the phonics component, and targets spelling.

- *Synonyms & Antonyms:* a picture is displayed and named. The individual must then select a word (from a selection of three) that is the synonym or antonym of the picture. This targets vocabulary.
- *Sentence Structure:* a sentence is chunked into words or phrases, and the learner must select the "who", "what", "where", "when", "how" or "why" of the sentence. This falls under the comprehension component, and targets an awareness of sentence structure.

Level 12: A Russian Circus

This focuses on end of Year 3 skills.

- *Irregular Plurals and Words:* in the identifying task, regular (singular or present) forms of a noun or verb and displayed over four possibilities of its irregular (plural or past) form, and the learner must select the correct irregular form. In the sentence completion task, two sentences are displayed, the first of which contains the regular form of a word and the second of which is missing the word's irregular form. The learner must select the correct irregular form (from a selection of three) to complete the sentence. This activity comes under the phonics components, and targets knowledge of common irregular plural nouns and past tense verbs.
- *Latin Prefixes:* the tasks here are similar to that of the *Simple Suffixes* activity from Level 10, but focuses on Latin prefixes instead. This falls under the structural analysis component of the programme, and targets knowledge of common prefixes and an awareness of the morphological structure of words.
- *Passage Fluency 1:* the learner reads a two-part passage that has 10 words missing. For each part, the individual must select the five missing words in less than one minute. Accuracy and rate are measured. The targets on-level text accuracy and fluency.
- *Similes & Metaphors:* in the completion similes task, the individual must complete a simile by choosing from three possibilities. In the meaning of metaphors task, the individual must select the correct meaning of a metaphor from three choices. This targets vocabulary.
- *Passage Comprehension 1:* the learner reads a passage and must then answer questions about the passage by selecting one of three possible answers for each question. If an incorrect answer is selected, explicit instruction on the type of question or higher order thinking skill required is given. The learner is then able to reread the passage and answer the questions again. This targets comprehension.

Level 13: The Indian Rainforest

Targets early Year 4 skills.

- *Spelling Rules 2:* The spelling dictated words task here is similar to that from the *Spelling Rules 1* task from Level 11. This activity also includes a constructing words task, where the learner hears a word and sees its base and suffix. They must then type the word by applying the spelling rule. This falls under the structural analysis component, and targets knowledge of common spelling rules used when adding suffixes to base words.

- *Latin Suffixes:* This is similar to the *Simple Suffixes* activity from Level 10, but tasks focus on Latin suffixes instead. This also falls under the structural analysis component, and targets knowledge of Latin-based suffixes and an awareness of the morphological structure of words.
- *Passage Fluency 2:* This is similar to the *Passage Fluency 1* activity from Level 12.
- *Idioms 1:* In the idioms meanings task, an idiom is presented alone and in context, and the learner must select the meaning of the idiom from three choices. In the review task, the individual must complete an unfinished sentence by selecting the idiom (from three possibilities) that best completes the sentence. This targets vocabulary.
- *Passage Comprehension 2:* This is similar to the *Passage Comprehension 1* activity from Level 12.

<u>Level 14: A Japanese Garden</u>

This focuses on end of Year 4 skills.

- *Prefix Meanings:* in the visual sort task, the learner must drag number prefixes into the appropriately numbered box (e.g. "tri" dragged to box 3). If the individual has dragged the prefix into the correct box, they hear the prefixes' meaning. The auditory recognition task is similar to that from the *Simple Suffixes* activity from Level 10, but focuses on prefixes. Similarly, the sentence completion task is also like that from the *Simple Suffixes* activity, but focuses on prefixes, includes sentence with the entire word missing, and has more word possibilities to choose from.
- *Sight Words 6:* this is similar to *Sight Words* activities from earlier levels. However, for the recognition task in this activity, the learner must highlight a spoken target word from a word scramble.
- *Passage Fluency 3:* this is similar to *Passage Fluency* activities from earlier levels.
- *Simple Analogies:* in the identifying related words task, the learner must select a word (from three choices) that most closely relates to a target word. In the recognising relationships task, three pairs of words are shown and the individual must select the pair that shows the type of relationship that is named. In the analogy completion task, the learner must complete an analogy by selecting the correct word from three choices. This falls under the vocabulary component of the programme, and targets an understanding of word relationships in simple analogies.
- *Passage Comprehension 3:* this is similar to *Passage Comprehension* activities from earlier levels.

<u>Level 15: The Great Barrier Reef</u>

Focuses on early Year 5 skills.

- *Root Meanings:* in the picture matching task, a root is defined and the learner must select the matching picture from four choices. In the auditory recognition task, a word is named and the student must select the box (from four choices) containing the root of the word. In the matching words to definitions task, a root is defined and the learner must choose the word (from three possibilities) that matches the definition. In the sentence completion task, the learner must drag a word (from three choices) to complete a sentence. This falls under the structural analysis component, and targets knowledge of meanings of Latin-based roots.

- *Sight Words 7:* this is similar to the *Sight Words 6* activity from Level 14.
- *Passage Fluency 4:* this is similar to *Passage Fluency* activities from earlier levels.
- *Multiple Meaning Words 2:* two sentences with blanks are displayed. The learner must select a multiple meaning word (from three choices) that completes both the sentences. This targets vocabulary.
- *Passage Comprehension 4:* this is similar to *Passage Comprehension* activities from earlier levels.

Level 16: A Hawaiian Paradise

This focuses on end of Year 5 skills.

- *Prefix Change Rules:* in the combining task, a prefix and stem of a word is displayed. The learner hears the combined word and must type it. In the spelling task, a word is spoken and the learner must type it. This targets structural analysis.
- *Spelling Rules 3:* the spelling dictated words task here is similar to that from the *Spelling Rules 1* task from Level 11. This activity also includes a combining base and suffix task, in which a base and suffix is displayed and the learner must type the combined word after it is dictated. This targets structural analysis and knowledge of spelling rules.
- *Passage Fluency 5:* this is similar to *Passage Fluency* activities from earlier levels.
- *Idioms 2:* in the identifying idiom meanings task, a sentence with an idiom is presented and the learner must select the meaning of the idiom from three possibilities. In the sentence completion task, a partial sentence is shown and the individual must select the idiom that best completes the sentence from three possible choices.
- *Passage Comprehension 5:* this is similar to *Passage Comprehension* activities from earlier levels.

Level 17: A Southwest Fiesta

This focuses on early Year 6 skills.

- *Greek Combining Forms 1:* in the picture matching task, the learner must select the picture (from four choices) that matches a named target word. In the visual sort task, the learner must sort words into the appropriate boxes, based on their suffixes. In the word construction task, the learner must combine two forms to construct a word. In the sentence completion task, the individual must choose a word (from three possibilities) that best completes a sentence. This falls under the structural analysis component, and targets knowledge of Greek combining forms.
- *Passage Fluency 6:* this is similar to *Passage Fluency* activities from earlier levels.
- *Shades of Meaning:* in the identifying common meanings task, the learner selects the “odd one out” from a selection of four words. In the ordering task, the learner must place three words in order according to their shade of meaning. This activity targets vocabulary.
- *Signal Words:* in the identifying signal words task, a sentence is shown with a highlighted transition word, and the individual must select a synonym for the word

from three choices. In the sentence completion task, a partial sentence is displayed and the learner must use the signal word to determine which of three possibilities best completes the sentence.

- *Passage Comprehension 6:* this is similar to *Passage Comprehension* activities from earlier levels.

<u>Level 18: The Ancient Greek Countryside</u>

This level focuses on end of Year 6 skills.

- Greek Combining Forms 2: This is similar to the Greek Combining Forms 1 activity from Level 17.
- Special Accent Rules: In the auditory recognition task, the learner hears a word and must select the word from a display of six words. In the identifying task, the learner sees and hears a word and must identify the accented syllable. In the sentence completion task, the learner must select the word (from three possibilities) that completes a sentence. These tasks fall under the structural analysis component, and targets knowledge of accent placement rules.
- Passage Fluency 7: This is similar to Passage Fluency activities from earlier levels.
- Complex Analogies: This is similar to the Simple Analogies activity from Level 14, but focuses on more complex analogies.
- Passage Comprehension 7: This is similar to Passage Comprehension activities from earlier levels

Lexia Strategies for Older Students:

This focuses on foundational reading skills, beginning at Year 1 level, but has a more age-appropriate user interface and topics. The content develops basic phonological awareness through advanced decoding skills, vocabulary development and comprehension activities. The activities involve high utility words and academic vocabulary.

Students are placed at an appropriate level for their abilities. However, if the individual struggles with any of the activities, the programme provides them with scaffolding by allowing them practice the skill with additional assistance. Once the learner is able to complete the task with scaffolding, they return to the standard, unassisted version of the task.

<u>Level 1</u>

- *Short Vowel Sounds:* contains four tasks. In the first task, the learner chooses vowels and hears their sound. In the second task, the learner matches short-vowel sounds to target words and pictures. In the third task, the learner hears a sound and must select the corresponding vowel. In the final task, the learner hears a word and must type out the initial vowel. This activity targets letter-sound correspondences for short vowels.
- *Consonant Sounds:* this activity involves two tasks. In the first task, the learner must complete the spelling of a spoken word or detached syllable by selecting the correct initial or final consonant, consonant diagraph or consonant blend. In the second task, which is timed, the individual must select spoken words or detached syllables as quickly as possible. This targets letter-sound correspondences and an awareness of initial and final sound segments within words.

- *b, p, d:* rhis consists of three tasks. In the first task, the learner must sort the letters b, d, and p, or words that include those letters, into the appropriate boxes. In the second task, the learner hears a word containing b, p or d in the initial or final position, and must click the box corresponding to the appropriate letter. In the final task, the learner must select b, d or p to complete a spoken word.
- *Middle Vowels:* the learner has to select the correct short-vowel letter to complete the spelling of a dictated word or detached syllable. This targets the automatic retrieval of letter-sound correspondences and sound segmentation for short vowel words.
- *Short Vowel Words:* the student must match a word with the correct picture, first untimed and then timed. This targets the automatic recognition of short vowel words.

<u>Level 2</u>

- *Letter Switch:* this activity involves three tasks. In the first task, the learner replaces a letter or letter cluster of a word or detached syllable to form a spoken word. In the second task, the learner hears a target word or detached syllable and must select the word from a list. In the third task, the learner must choose the correct word to complete a sentence. This targets sound segmenting skills for short and long (silent e) vowels.
- *Short & Long Vowels:* this activity consists of three tasks. In the first task, the learner has to sort spoken words, based on whether they have long or short vowels, as quickly as possible. In the second task, the learner has to progress through a maze by choosing between two spoken words that are contrasted by a silent e. In the final task, the learner must construct spoken words. This targets an understanding of the concept that a silent e acts as a signal for the long vowel sound.
- *Sight Words:* this involves three tasks. The first task involves the learner selecting spoken words from a random sample of visually presented familiar words. In the second task, the individual has to highlight target words from a word grid. In the final task, the learner initially types a spoken word that is also on screen, then types in missing letters of the target words, and then types in the target words without a visual model. This activity targets fluency for Year 2 and Year 3 sight words.
- *Two Syllable Words 1:* this activity involves three tasks. In the first task, the learner hears a word and must spell it out by matching syllables. In the second task, the learner matches two syllables to spell out familiar words. In the final task, the learner has to complete a sentence by selecting the most appropriate word form several possibilities. This targets reading of two syllable short vowel and long vowel words.
- *Sentences & Paragraphs:* the learner has to complete a sentence by selecting the correct word. A picture that illustrates the theme accompanies the sentences/paragraphs. Targets reading comprehension.

<u>Level 3</u>

- *Vowel Digraphs: t*his activity involves four tasks. In the first task, the learner must complete the spelling of a spoken word by choosing the appropriate vowel combination. In the second task, the learner has to select visual representations of spoken words. In the third task, the learner has to sort words based on the vowel combination. In the final task, the individual practices reading vowel-combination words in sentences. This targets letter-sound correspondences for vowel combinations and automatic recognition of words with these vowel combinations.

- *Vowel –r:* this involves three tasks. In the first task, the learner must select a spoken target word from a group of words containing vowel –r combinations. In the second task, the learner must select a spoken word by ordering letters on screen. In the final task, the individual has to select the correct vowel –r combination to complete a word in a sentence. This activity targets letter-sound correspondences for vowel –r combinations.
- *Suffixes:* this activity involves three tasks. With the first task, the learner has to sort words into boxes based on their suffixes. In the second task, the learner selects spoken words from a list. The word is then displayed without the suffix, which the individual must type in. In the third task, the learner has to choose the missing suffix and place it next to the correct word to complete a sentence.
- *Two Syllable Words 2:* this is a follow on of *Two Syllable Words 1* from Level 2.
- *Paragraphs 1:* the learner has to complete a paragraph with missing words by typing in the appropriate sight words from a list. The paragraph is presented with a picture that illustrates the theme. This activity targets reading comprehension.

<u>Level 4</u>

- *Syllable Types:* this activity involves two tasks. In the first task, the learner hears a detached syllable and must select the correct syllable and sort it into the appropriate file card. In the second task, the learner constructs two syllable words by matching two syllables. The word is presented in a column and the learner has to type it out. Targets automatic word recognition of two syllable words.
- *Two Sounds of C & G:* this activity consists of four tasks. In the first task, words have to be sorted into boxes based on whether they have a hard or soft c or g sound. In the second task, the individual has to select a spoken word from a group of words. In the third task, the learner must complete an incomplete word by typing in the missing letters. In the fourth scene, the student has to match the appropriate ending of a sentence to its beginning. This targets an awareness of the rules regarding the pronunciation of c and g.
- *Three Syllable Words:* this involves three tasks. In the first task, the learner has to rearrange detached syllables to form a three syllable word. In the second task, the learner copies a word by typing in the syllables. In the final task, the learner has to arrange detached syllables from a grid to form words, without hearing the words first.
- *Paragraphs 2:* this is similar to the *Paragraphs 1* activity from Level 3.

<u>Level 5</u>

- *Anglo Saxon:* this activity involves four tasks. In the first task, the learner hears a prefix or suffix and must select it from a group of affixes on screen. In the second task, the learner hears a target word and must then select the affix and place it next to the root to form the target word. In the third task, the learner has to type an affix from memory on a blank in front of a root word. Scaffolding is provided if the individual struggles. In the final task, the learner has to select the appropriate suffix to complete a sentence.
- *Latin:* this activity involves five tasks. In the first task, a prefix is displayed next to a box of letter strings that may or may not match the prefix. The learner has to

select the letter strings that match the prefix. In later units, the individual must select the dictated suffix instead. In the second task, the learner uses letters to spell out the affix of a spoken word. In the third task, the learner has to sort the affix and root of words into the appropriate boxes. In the fourth task, the learner has to match roots to affixes to form a word. In the final task, the learner has to complete sentences by typing in the missing affix. Units 7 to 10 involve slightly different tasks. In one task, the learner must select the prefix (from three possibilities) that indicates what prefix change has occurred to the target word. In the other task, a root is shown with three prefixes and possible changes. The learner hears a word and must choose the correct word to combine with the prefix and sort it into the appropriate box. Targets word attack strategies.

- *Special Accents:* tasks vary depending on each unit. Tasks place emphasis on accent placement rules and pronunciation. Tasks also involve students matching affixes, identifying affixes and words containing affixes and typing in words and affixes. In every unit, sentences are included that assist in the application of rules to contextual information.
- *Prefix & Root Meanings:* again, tasks vary depending on each unit. Tasks focus on constructing and reading words with common Latin roots and prefixes related to number and negotiation. Prefix and root meanings are also emphasised, and sentences and paragraphs are used to reinforce conceptual application to conceptual material. Targets vocabulary.
- *Greek:* tasks vary depending on the units. The meanings of combining Greek forms are emphasised and words are analysed according to meaning. Meaning is reinforced throughout the activity through the use of phrases. Targets vocabulary and word identification of words with common Greek forms.

What claims does the company make / what does the programme target?

Lexia Reading Core5 is for children of all abilities in Years 1 to 6. Lexia Strategies for Older Students is aimed at individuals in Years 7 to 13 who have reading difficulties and need remediation. Skills targeted by each activity are described above.

Evidence for efficacy:

Macaruso, Hook, & McCabe (2006):

In this study, the reading performance of first graders (*n* = 43; treatment group) who used Lexia programmes in conjunction with daily reading instruction was compared to that of control students (*n* = 84) who were only receiving classroom instruction. Students used the now retired Lexia Reading programme as well as Lexia Strategies for approximately 6 months. The Gates-MacGinitie Reading Test (GMRT) Level BR was used to measure reading performance, and included assessments of letter-sound correspondences and recognition of basic story words.

Results revealed that while both treatment and control groups made significant gains on GMRT measures from pre- to post-test, there were no significant differences between groups at either pre-test or post-test.

A subsequent analysis was conducted only looking at "at risk" students from the sample (*n* = 15 for treatment group; *n* = 15 for control group). There were no significant differences between groups at pre-test, and both groups made significant gains from pre- to post-test. However, there was a significant difference on reading performance at post-test, with the difference favouring the treatment group. Further analyses revealed that this difference was specific to the letter-sound correspondences measure. Additionally, "at risk" students in the treatment group were performing at the same level as the treatment group at post-test, despite showing lower scores at pre-test. A correlation analysis on the "at risk" subsample also revealed that there was a positive relationship between reading performance gain scores and the number of skills units completed.

Limitations: one of the authors of the article, Robert McCabe, was the Director of Research and Product Management at Lexia Learning Systems. Therefore the study is not independent. The other authors also acted as consultants in the development of the programme. Though the study used an active control group, it would have also been go to have an alternative treatment group to determine how Lexia compares to other intervention programmes. Sample sizes were small for the subgroup analysis. The study uses an earlier version of the Lexia programme.

Macaruso and Walker (2008):

Kindergarten children in classes (*n* = 26) receiving Lexia Early Reading (now discontinued) were compared to control children from matched classrooms (*n* = 45). Treatment children used Lexia for approximately 6 months, and completed a minimum of 45 sessions. All students also received the same daily reading instruction. All participants were measured on the DIEBELS initial sound fluency (phonological awareness) and letter naming fluency subtests at pre-test. Letter naming fluency was also measured at post-test, as well as the segmentation fluency subtest (a different measure of phonological awareness). The change in the DIEBELS measure of phonological awareness was because qualitative changes occur to pre-literacy skills during kindergarten. The GMRT, Level PR, was also administered to students, but only at post-test as there is no measure that can be given to kindergartners at the start of the school year (i.e. pre-test). GMRT subtests included literacy concepts, oral language concepts, letter and letter sound correspondences, and listening comprehension.

Results revealed that there were no significant differences between groups on the DIEBELS measures at pre- and post-test. With the GMRT measures, significant differences were observed between groups (favouring the treatment group) on the oral language concepts subtest only.

Results from subsequent analyses looking only at "low performers" (these were the four students from each of the three treatment and three control classes with the lowest scores) were consistent with that of the main analyses. However, effect sizes were stronger when looking at low performers than when looking at the whole sample.

Limitations: the use of different DIEBELS phonological awareness measures at pre- and post-test and the lack of pre-test GMRT measures is a limitation. Initially, there were more students in the treatment group but several had to be excluded as teachers were not always consistent with treatment implication, thus several students did not reach the minimum 45 sessions criterion. The authors have been affiliated with Lexia Learning Systems, and also had assistance from members of the company. Consequently, it is not clear how independent the study may be. The discontinued Lexia Reading programme was used. There was no alternative treatment group in the study.

Macaruso and Rodman (2009):

This study compared the reading, spelling and oral language skills of struggling middle school students who used Lexia Strategies for Older Students (*n* = 32) to that of control students who were taught by the same teacher but did not receive Lexia assistance (*n* = 13). The word attack, letter-word identification, reading fluency, reading vocabulary, passage comprehension, oral comprehension and spelling subtests from the Woodcock-Johnson lll Tests of Achievement were used to assess the participants at pre- and post-test.

Results revealed that there were no pre-test differences between the two groups. The Lexia treatment group made significant gains on the word attack, letter-word identification and passage comprehension measures from pre- to post-test. In contrast, the control group only made significant gains on passage comprehension. Groups were then compared on measures in which at least one group made significant gains. The authors found that significant differences favouring the treatment group were found for the word attack measure only.

<u>Limitations:</u> one of the authors, Alyson Rodman, is part of Lexia Learning Systems, therefore the study is not independent; no alternative treatment group was used; there was only one measure, out of several reading and language-related skills assessed, for which the treatment group made significantly greater gains relative to the control group.

<u>*Macaruso and Rodman (2011):*</u>

This article describes two studies.

<u>Study 1</u>

In Study 1, 19 treatment pre-schoolers and 19 control pre-schoolers were compared on reading-related measures. All students were involved in a Language and Emergent Literacy Skills programme, but the treatment students also received Lexia training. GRADE Level P assessments were administered at pre- and post-test. GRADE Level P has three domains and seven subtests. The phonological awareness domain consists of the sound matching and rhyming subtests, the visual skills domain consists of the picture matching and picture differences subtests, and the concepts domain involves the verbal concepts and picture categories subtests. There is also the additional listening comprehension subtest.

Results revealed that there were no significant differences between groups at pre-test. The treatment group made significant gains on overall GRADE scores from pre- to post-test, whereas the control group showed no gain. Further analyses revealed that there were significant group differences at post-test, favouring the treatment group, for the phonological awareness domain and the sound matching subtest.

<u>Study 2</u>

This study focused on low-performing kindergarteners, separated into treatment (n = 47) and control (n = 19) groups. All students participated in daily explicit phonics instruction for reading. Additionally, the treatment group completed Lexia exercises for approximately 7 months.

GRADE Level K was administered at pre- and post-test. This Level has two domains and seven subtests. There is the same phonological awareness domain and corresponding subtests from Level P. There is also the early literacy skills domain, which involves the print awareness, letter recognition, and same and different words subtest. There were also the additional listening comprehension and word reading subtests.

Results showed that there were no significant differences between groups on pre-test measures. Both groups made significant gains on overall GRADE, and on all domain and subtest measures. However, there was a significant difference between the two groups at post-test, with the results favouring the treatment group. Comparing the two groups on the domain and subtest measures at post-test results revealed that the treatment group showed greater letter recognition and word reading scores, though only word reading differences were significant when controlling for pre-test scores.

Limitations: teachers were not always consistent with implementation, resulting in a loss of some participants from the initial sample. Alyson Rodman is part of Lexia Learning Systems, therefore the study is not independent. An earlier, now retired version of Lexia Reading was used. No alternative treatment group was included in the study; There only seemed to be a benefit to using Lexia for one of the several measures assessed in Study 2.

Evidence against efficacy:

Ness, Couperus and Willey (2013):

The efficacy of the Lexia Reading programme in “at risk” students from a New Zealand Decile 1 primary school was evaluated in this study. 37 participants, ranging from Years 1 to 6, were recruited and randomly assigned to treatment or control groups. All students followed the normal class curriculum, but the treatment group also participated in Lexia exercises for at least 100 mins per week during a school term. Participants were assessed on the word reading, reading comprehension, spelling and pseudoword subtests of the Wechsler Individual Achievement Test (WIAT-ll) at pre- and post-test (however, 5 year olds were treated as pre-schoolers, and thus could only be assessed on word reading and spelling).

The study found that there were no significant differences between groups on any of the WIAT-ll substests at either pre- or post-test.

Limitations: the sample size was somewhat small; an earlier version of Lexia Reading is used; the authors noted that when learners struggle frequently on a task, they are flagged as needing additional one-on-one instruction. The school in this study was not informed of this requirement, and also decided not to deliver the one-on-one instruction due to time constraints. As all students were flagged at some point, it is possible that the null results here were due to the lack of this one-on-one instruction. However, the authors argue that this would mean that the benefits of Lexia are then not due to computer-assisted instruction, but due to one-on-one instruction.

Overall, there seem to be more studies supporting Lexia Reading’s efficacy than not. However, Ness et al. (2013) noted that the Macaruso studies discussed above (specifically Macaruso et al., 2006; Macaruso & Rodman, 2009; and Macaruso & Walker, 2008) do not provide consistent results. Additionally, peer-reviewed studies looking at Lexia Reading (excluding those looking at Lexia Strategies) have all been conducted on the earlier Lexia Reading programme, which has now been replaced by Lexia Core5. Therefore, we cannot comment on the efficacy of the newer Core5 programme. Additionally, there are a lack of studies looking at Lexia Strategies for Older Students and no studies comparing Lexia to alternative remediation techniques. As such, we cannot comment on Lexia Strategies’ efficacy as an intervention. While Lexia Reading seems promising, is recommended that further independent and peer-reviewed research be conducted.

Price:

The price of Lexia Reading Core5 varies depending on the type of license purchased. According to the Washington Learning Source website (http://www.walearningsource.org/_bymfg_92-0-1.html), a one year single student licence costs US$33.25, and an unlimited licence costs US$9,405. On site training costs US$1,212.50. Additional prices are displayed on the Washington Learning Source website.

A pricelist from Lexia Learning NZ (http://www.lexialearning.co.nz/docs/Lexia_Pricelist.pdf) prices Lexia Strategies for Older Students at NZ$225 if more than 10 licences are bought. Training for one school is NZ$500. Prices exclude GST. (*Note: Lexia Reading prices are also included in this pricelist, but Core5 has now replaced this programme*).

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K Lumosity

Website / for more information see:

http://www.lumosity.com and http://www.lumosity.com/hcp/research/completed.

What it involves:

Lumosity markets an online brain training programme to the general public (aged between 18-89) involving (at the time of writing) 56 discrete adaptive games, broadly grouped into five categories, being memory, attention, speed, flexibility and problem solving. The programme can be accessed via a web browser, and also via apps on smartphones and tablets.

When users first create an account, they must select which aspects of cognition they would like to improve using Lumosity. The aspects users can select from are:

Memory • remembering patterns and locations • associating names with faces • keeping track of multiple pieces of information in your head • recalling sequences of objects and movements	*Attention* • dividing your attention between multiple tasks and demands • attending to key information within a large area • ignoring distractions • quickly pointing out patterns

Speed • decision-making in time-sensitive situations • quickly recalling recent information • reorienting yourself as perspectives change • reacting quickly	*Flexibility* • rapidly selecting words from your mental vocabulary • quickly adjusting to shifting rules • inhibiting initial responses • switching between tasks efficiently
Problem Solving • using logical reasoning • making quick and accurate estimations • calculating figures in your head • planning efficient routes	

They are then required to complete a 'Fit Test' to establish a baseline for training. This involves assessment using three games — when we tried the software, these were 'Train of Thought', 'Memory Matrix' and 'Speed Match' (see below).

Once users have completed this process, they are given the option to pay to access their personalised training program. This involves playing adaptive games selected from the following series:

Memory:

- *Face Memory Workout*: an *n*-back task where n can vary (up to at least 3). Users have to indicate whether the currently presented face is the same as one presented *n* faces previously. Assessment is based on speed and accuracy.
- *Familiar Faces*: the user takes the place of a cashier at a restaurant. The user's first job is to greet customers, at which point s/he must either ask or type their names. Each customer has a unique name, which never changes. Asking customers what their name is incurs a points penalty. Further, once customers have been greeted, they place an order. The user must remember a number of these orders at a time and — when the food has been prepared — match the orders with the correct person.
- *Follow That Frog*: a spatial span task where the user must remember and recreate the path of a frog on a number of lily pads. The number of jumps the user must remember increases with the number of correct answers.
- *Memory Lane*: a dual *n*-back task where n can vary. A figure appears in a particular window of a house, and a letter is spoken at the same time. The user must press the left arrow key if the currently presented figure's location is the same as one presented *n* times previously, and press the right arrow key if the letter spoken is the same as that spoken *n* times previously.
- *Memory Match*: a timed *n*-back task with *n* of 2. Users have to indicate whether a visual stimulus is the same as one presented two previously.
- *Memory Match Overload/Overdrive*: a timed *n*-back task with *n* of 3. Users have to indicate whether a visual stimulus is the same as one presented two previously.

- *Memory Matrix*: a pattern of lit tiles is briefly shown on a grid (which expands or contracts depending on the appropriate difficulty level). The user must exactly reproduce the pattern shown.
- *Moneycomb*: the user is shown a number of tiles, some of which contain bronze, silver or gold coins. The user must click on the tiles that contain the coins in ascending order of value (i.e., bronze coins first, gold coins last).
- *Monster Garden*: users are shown a grid representing a garden. They are briefly shown which squares in the grid contain monsters and which contain beets. They must then guide a farmer to a flower in the garden by clicking a path of squares which does not contain any monsters.
- *Pinball Recall*: users are shown a grid with bumpers representing the inside a pinball machine. The grid fades from view, and then a light is shown which indicates to the user from where the ball will be fired. The user must predict where the ball will finish, taking into account how it will bounce against the bumpers.
- *Rhyme Workout*: a timed *n*-back task with *n* of 1 or 2. Users have to indicate whether a rhyming word (presented visually) matches that presented *n* times previously. Similar to Memory Match, but uses rhyming words instead of symbols.
- *Rotation Matrix*: the same as Memory Matrix, except that the grid rotates 90 degrees after the pattern is shown but before the user reproduces it.
- *Tidal Treasures*: a number of different objects are shown washed up on a beach. The user must click on each object only once (i.e., must click on a different object each time). More objects wash up throughout the game.

<u>Attention:</u>

- *Train of Thought*: in this game the user must manage a series of switches to ensure a series of coloured trains reach their correspondingly coloured stations. More difficult levels require you to manage a greater number of trains, which appear on the grid at a faster pace.
- *Trouble Brewing*: in this game users take the place of a barista. They must prepare the correct coffees (in terms of ingredients and size) as shown on another screen, and not let the cups overflow. Points are awarded for coffees made correctly, and lost for wasted (i.e. incorrectly prepared) coffees.
- *Star Search*: different kinds of objects (which may be, for example, different shapes, colours and textures) are shown. Users must click on the 'odd object out'. For example, there might be multiple red flat triangles, blue hatched semicircles and green dotted hexagons, but a blue flat semicircle. The user would be required to click the flat blue semicircle.
- *Eagle Eye*: an arrangement of shapes, comprised of one eagle hidden amongst other non-bird distractors, is very briefly flashed on the screen. At the same time a digit is flashed in a square in the centre of the screen. The user must notice, remember and then click on on the location of the bird. They must then indicate the digit shown.
- *Lost in Migration*: based on the flanker paradigm (Kesler, Lacayo, & Jo, 2011). Users are shown birds in various formations, and required to press the arrow key corresponding to the direction the bird in the middle is facing.

- *Rhythm Revolution*: users are required to tap a rhythm with the space bar on their keyboards. At first the task is aided by visual cues (on a spinning record) but these disappear as the user gets better. The rhythm also gets faster and more complex.
- *Birdwatching*: a bird and a letter flash up simultaneously on the screen. Users must click where the bird appeared, at which point they are shown how accurate their click was. They must then type in the letter that is shown. As the user becomes more proficient the space between the bird and letter increases, and the length of time for which the bird and letter are shown decreases.
- *Observation Tower*: a number of bubbles are presented on the screen. Numbers are briefly flashed inside the bubbles. The user must click on the bubbles in order, based on the value of the numbers they contained. Clicking on the correct sequence gets the user points to build a taller tower.
- *Space Junk*: a number of space-related objects are simultaneously and very briefly flashed on the screen. The user must indicate how many objects he or she could count.
- *Playing Koi*: users must feed all the koi in a pond only once. As the koi look identical this requires users to keep track of them as they move. As users progress, there are more koi in the pond, distractor fish (which should not be fed) start to appear, the fish swim in different patterns, and the time between feedings becomes longer.
- *Top Chimp*: similar to *Observation Tower* although somewhat more complex interface where poker chips replace bubbles, and where the user has control over how many chips they want to 'bet on' (on which will briefly flash a number, the user's task being to click the chips in order of the numbers flashed) to win against a chimp opponent.

<u>Speed:</u>

- *Penguin Pursuit*: the user takes the place of a penguin, which must race (using the arrow keys) through a maze against a rival penguin to be the first to get the fish. At higher levels, the maze rotates, but the arrow key controls do not (i.e. the user might need to press the left arrow key to go up).
- *River Ranger*: animals (some of which look remarkably similar) are shown in a river. The user must click on an animal s/he has not clicked before. Increasing numbers of animals appear at a time as the user goes through the levels, and the length of time for which they are shown decreases.
- *Spatial Speed Match*: a simple *n*-back task with *n* of 1; users are shown an arrangement of three circles, one of which is blue. They are required to press the right arrow key if the location of the blue circle matches the previously shown arrangement, and the left arrow key if it does not. Users are scored based on speed and accuracy.
- *Speed Match*: a simple *n*-back task with *n* of 1; users are shown various symbols and asked to press the right arrow key if the symbol presented matches the one immediately before it, and to press the left arrow key if it does not. Users are scored based on speed and accuracy.
- *Speed Match Overdrive*: the same as Speed Match except that users must also indicate whether the second stimulus is a 'partial' match — i.e., same colour or shape (but not both).

- *Speed Pack*: based on Thurstone's Punched Holes task. Users are shown an open suitcase. This contains a grid in each compartment. The user's job is to place an item (as fast as possible) onto an empty space in the grids such that when the suitcase is folded, no two items will be on top of each other.
- *Splitting Seeds*: an even number of seeds are arranged on the screen. The user's job is to rotate a twig as fast as possible so that it splits the seeds exactly in half.

Flexibility:

- *Brain Shift*: two cards (one above the other) are shown to the user. A letter together with a number may appear in either. If they appear in the top card, the user must indicate whether the number is even (left arrow key press for no, right arrow key press for yes). If they appear in the bottom card, however, the user must indicate whether the letter is a vowel.
- *Brain Shift Overdrive*: the same as Brain Shift except that there are four cards. The questions are:
    - top left – is the number even?
    - bottom left – is the number odd?
    - top right – is the letter a vowel?
    - bottom right – is the letter a consonant?
- *Color Match*: based on the Stroop task (Kesler, Lacayo, & Jo, 2011). Users are shown two words — the left labelled 'meaning' and the right labelled 'color'. They have to indicate if the colour of the word on the right matches the meaning of the word on the left.
- *Disconnection*: a number of puzzle pieces with cartoon faces are shown. Users must match these as quickly as possible by moving them next to one another.
- *Disillusion*: a number of puzzle pieces with coloured shapes are shown. Puzzle pieces can be classed as either vertical (notches at top and bottom) or horizontal (notches at left and right). Users must match vertical puzzle pieces as quickly as possible by moving those with symbols of the same colour next to each other. They must match horizontal puzzle pieces as quickly as possible by moving those with symbols of the same shape next to each other.
- *Ebb and Flow*: leaves are presented on a screen and change colour between green and brown. When they are green, the user must press the arrow key corresponding to which way they are pointing. When they are brown, the user must press the arrow key corresponding to which way they are moving.
- *Robot Factory*: based on the go/no-go task, this is a game designed to train response inhibition. Users are presented with outlines of robots they are required to build. Parts for these robots are presented on three pedestals. Users must press the arrow key corresponding to the pedestal (left, right, down) if the part is needed but inhibit their response if it is not (as indicated by a cross that appears under the part).
- *Word Bubbles/Word Bubbles Rising*: a verbal fluency task. Users must type as many words they can think of beginning with a particular set of letters in three minutes. These must be of varying lengths to achieve a high score.

Problem Solving:

- *Addition Storm*: a number of animals rain from the sky. Each animal contains a simple addition question. Animals disappear once the correct answer to the question they contain has been provided. The game is over once three animals reach the ground.
- *By the Rules*: somewhat similar to the Wisconsin Card Sorting Test. Users are shown a single card (on which is printed one or more shapes) and required to indicate whether the card follows the rule or not. The particular rule in play has to be ascertained via trial and error.
- *Chalkboard Challenge*: users are presented with a blackboard divided in two. Single numbers and/or equations are presented on each side. Users must indicate which side is larger (e.g., 18 vs. 12 + 9).
- *Division Storm*: a number of balls rain from the sky. Each ball contains a simple division question. Balls disappear once the correct answer to the question they contain has been provided. The game is over once three balls reach the ground.
- *Multiplication Storm*: a number of fruits rain from the sky. Each fruit contains a simple multiplication question. Fruits disappear once the correct answer to the question they contain has been provided. The game is over once three fruits reach the ground.
- *Pet Detective*: a game designed to train route planning. A grid of roads is presented on which appears lost pets and corresponding houses to which pets need to be returned. Users must plan a route to return the lost pets to their owners using the shortest path possible.
- *Raindrops*: simple maths equations (addition, subtraction, multiplication and division) appear inside rain droplets which fall from the top of the screen. Users must enter the correct answer to the equation shown before the droplet reaches the puddle at the bottom of the screen.
- *Route to Sprout*: users are presented with grids of various shapes which contain a seed, a hole in which the seed should be planted, and a number of ladybugs. Users must plan and execute the most efficient (i.e., requiring the least clicks) route to get the seed to its hole.
- *Subtraction Storm*: a number of cupcakes rain from the sky. Each cupcake contains a simple subtraction question. Cupcakes disappear once the correct answer to the question they contain has been provided. The game is over once three cupcakes reach the ground.
- *Word Sort*: similar to By the Rules but the cards shown contain words instead of shapes. Users are shown a single card (on which is printed a word) and required to indicate whether the card follows the rule or not. The particular rule in play has to be ascertained via trial and error.

Courses

Lumosity's subscribers have access to all of the above games whenever they want. However, the website prescribes an individualised training regime and sends periodic training reminders based on the user's goals and performance.

Assessment

Users are continually provided with feedback about how their performance is improving with training. This feedback takes the form of:

- Scores and high scores from individual games.
- The *Brain Performance Index* (BPI): this indexes a user's cognitive performance across time and games. It can be further broken down into a number of subscores, namely memory, attention, speed, flexibility and problem solving. Users are told (via percentiles) how they compare to other users on their BPI and subscales.
- *Lumosity Points*: these are effort based, accruing to the user simply by completing more games.

Lumosity also offers standalone assessment tools to clinicians and researchers. Sternberg, Hardy, Katz, Ballard, and Scanlon (2012) describe the Brain Performance Test (BPT) which comprises six assessments as follows:

Assessment	**Task Description**	**Measure**
Go/No-Go	Users must click as fast as possible when one kind of fruit appears, but must not respond if any other kind of fruit appears.	Response time.
Trail-making A	Users must connect a series of dots containing numbers going from smallest to largest.	Completion time.
Trail-making B	Users must connect a series of dots containing numbers and letters like so: 1 to A to 2 to B to 3 to C...	Completion time.
Arithmetic Reasoning	Users must answer as many basic arithmetic problems (which are written in words) as they can in 90 seconds.	Correct – incorrect.
Reverse Memory Span	Users are shown a series of tiles. They must repeat the pattern flashed in reverse order.	Maximum span achieved.
Grammatical Reasoning	Users must respond to as many true/false logic questions as they can in 90 seconds.	Correct – incorrect.

What claims does the company make / what does the programme target?

Lumosity's website is at the time of writing (early 2015) relatively vague as to who the programme targets and what benefits users should expect to see. What is promised is simply an enjoyable, game-based brain-training programme that mimics exercises created by neuroscientists, and is likely to be of interest the general public.

This is in contrast to previous iterations of Lumosity documentation. These (Lumosity, 2009) describe, in addition to use by the general public, specific training courses designed to improve students' performance in school, and others to remediate neurological disorders like ADHD and traumatic brain injury.

Evidence for efficacy:

Lumosity's website provides "13 summaries of peer-reviewed papers and conference presentations on the efficacy of Lumosity training". Some studies have indeed been independently published in peer-reviewed scientific journals. They include:

<u>*Kesler et al. (2013):*</u>

This pilot study, published in *Clinical Breast Cancer*, used a waitlist control design to test whether Lumosity training could feasibly remediate some of the long-term cognitive deficits that accrue in breast cancer survivors. 41 survivors (on average 6 years post-therapy) participated in the study. 21 were assigned to the active condition, and 20 to the waitlist condition. Each completed 48 sessions (of 20–30 minutes) of adaptive training using 13 different Lumosity exercises. The authors do not list exactly which Lumosity exercises were used, although say:

> *In summary, the training tasks were composed of switching games (eg, based on the spatial location of the stimulus, participants responded to either a specific number or a specific letter of the stimulus), mental rotation games (eg, navigate a rotating maze), n-back memory games (eg, determine if the current picture or symbol matched the one shown 1 or 2 screens back), spatial sequencing memory games (eg, recall the location of coins and then find them in the order of their value), word stem completion games (eg, use various word stems such as "cog" to produce as many different words as possible), route planning (eg, navigate a maze by using the fewest number of moves possible), and rule-based puzzle solving (eg, determine if groups of figures follow an implicit rule).*

The researchers used a number of tests to assess the effect of training, including the Wisconsin Card Sorting Test (WCST), the letter fluency test from the Delis-Kaplan Executive Function System (assesses executive function and language), the Hopkins Verbal Learning Test Revised (HVLT-R) (assesses verbal memory), the digit span and symbol search subtests of the WAIS-IV. A self-report measure of executive function, the Global Executive Composite score of the Behavioural Rating Inventory of Executive Function (BRIEF), was also used. Baseline tests were performed no more than 3 days before beginning the training program, or after completing their baseline cognitive testing

Analysis revealed that those in the active condition demonstrated significant improvement in their WCST scores compared with the waitlist control group. They also improved significantly their scores on the letter fluency and symbol search tests, and improvement on the HVLT-R approached significance. There was, however, no significant difference in digit span scores, nor on global BRIEF scores (although the authors did conduct exploratory analysis on BRIEF subscales which suggested significant improvements on the planning and organization subscales).

Limitations: passive control only, so does not control for motivational/Hawthorne effects; waitlist control, so difficult to assess follow-up; small sample size, so hard to statistically address effect of disease and treatment history; does not provide evidence of transfer to real-world tasks.

Kesler, Lacayo, and Jo (2011):

This pilot study, published in *Brain Injury*, sought to investigate whether training with Lumosity exercises could feasibly remediate impaired executive function in children who survived leukaemia or brain tumours. 23 paediatric cancer survivors (aged 7–19) participated in the study. The participants had to be at least 7 years old, have completed their cancer treatment at least six months prior to the study, and show impaired executive function (defined as at least 1 SD below the test normative mean or their own Full Scale IQ scores on two or more executive function tests). The 19 participants who completed the intervention each underwent 40 sessions (of 20 minutes) of training. This was supposed to be across an 8-week period although most in fact required longer.

The researchers used a range of tests to assess the effect of training. The tests administered differed for those aged between 7-16 and those aged between 17-19. Those aged 7-16 underwent screening using the WISC-IV, the List Memory and Picture Memory components of the Wide Range Assessment of Learning and Memory 2nd Edition (WRAML2), the NEPSY II Animal Sort (to assess cognitive flexibility), the Woodcock-Johnson 3rd Edition (WJ-III) Cancellation Test (to assess attention and processing speed), and the Motor Free Test of Visual Perception 3rd Edition (MVPT-3) (to assess spatial relationships, visual discrimination, and visual memory). Those aged 17–19 undertook the WAIS-III instead of the WISC-IV and the Delis Kaplin Executive System (DKEFS) Sorting Test instead of the NEPSY II Animal Sort, but otherwise underwent the same testing.

Participants demonstrated (statistically) significant improvement between pre- and post-intervention testing in the Processing Speed Index of the WISC/ WAIS, the sort tests, and the List Memory and Picture Memory components of the WRAML2. Once the data were subjected to a Jacobson-Truax RCI analysis to account for practice effects, only changes in processing speed index and sort test scores were classed as clinically significant. Encouragingly, however, many participants' scores on these tests not only improved, but also fell post-intervention within the normative distribution, allowing a classification of 'recovered'.

The researchers also used fMRI to investigate the neural correlates of training. They observed significant increases in dorsolateral prefrontal cortex activation.

Tasks used: 6 — Spatial Speed Match, Monster Garden, Lost in Migration, Birdwatching, By the Rules, Colour Match.

Limitations: lack of a control group — improvement could be due to practice effects (although the RCI analysis was conducted); could not control for differential demographic and medical effects due to lack of statistical power; somewhat surprising that working memory and visual attention were not improved by the training program.

Kesler, Sheau, Koovakkattu, & Reiss (2011):

This pilot study, published in *Neuropsychological Rehabilitation*, sought to investigate whether the teaching of a mathematics strategy known as 'decomposition' coupled with practice of this strategy using Lumosity exercises could feasibly remediate deficits in mathematics skills in girls with Turner syndrome (TS). 16 girls with TS (7–14 years) participated in the study. They had to have been exposed to single digit addition to be eligible to participate.

Training consisted of:

(1) Instruction regarding the use of the 'decomposition' strategy for mathematics — this involves "decomposing math problems into smaller problems that are easier and/or already memorised. For example, 39 + 12 = 39 + 10 + 2."

(2) Lumosity games — namely, Chalkboard Challenge, Raindrops and By the Rules. Participants were required to train for 20 minutes per day, five days per week for six weeks.

The researchers looked at a number of outcome measures to determine the interventions' efficacy. These included:

- maths skills as assessed by the KeyMath Diagnostic Assessment (3rd Edition) — contains Basic Concepts, Operations and Applications subscales;
- "math-related" cognitive skills including:
    - the WISC-IV Working Memory (WMI) and Processing Speed (PSI)) indices;
    - the sky search subtest of the Test of Everyday Attention for Children — to assess attention;

- the animal sorting subtest of the NEPSY-II — to assess cognitive flexibility; and
- the Motor-free Visual Perception Test (3rd Edition, MVPT) to assess visual-spatial processing.

These tests were administered twice — first within 1 week prior to beginning training to establish a baseline, and then within 1 week after completing training. The researchers also collected fMRI data to assess the neural correlates of any improvements seen.

Linear mixed modelling (using age and PRI as covariates) revealed significant increases in participants' KeyMath Total, Basic Concepts and Operations post-intervention scores, although no significant changes were seen in KeyMath Applications score. Further significant increases could be seen in participants' processing speed index, Animal Sort and MVPT scores. An RCI analysis was also conducted, the researchers concluding that the increases in KeyMath Total and Basic Concepts scores, PSI, Animal Sort and MVPT test scores were also clinically significant and could be classified as 'recovered'.

fMRI data showed a decrease in frontal-striatal and mesial-temporal activation but an increase in parietal lobe activation after participants completed the training programme. The authors (p. 447), citing Rivera et al. (2005) concluded this "may imply that less proficient math performers rely on attention, memory and/or verbal-based strategies as these are typically subserved by frontal-striatal and temporal regions, while more proficient performers utilise more spatial/retrieval-based strategies that are associated with parietal regions."

Limitations: multiple treatments, so unknown how important the decomposition training was; no control group — so practice effects and regression to the mean are not controlled for; small sample size.

Finn and McDonald (2011):

This pilot study, published in *Brain Impairment*, used a waitlist control design to investigate whether Lumosity training could improve cognitive functioning (related to attention, processing speed, visual memory and cognitive control) in older adults with mild cognitive impairment (MCI). 25 participants diagnosed with MCI (amnestic and/or multiple domain) according to standardised criteria were randomly allocated to the treatment (*n* = 12) and waitlist (*n* = 13) groups. Participants completed 30 training sessions of training, completing four or five cognitive exercises per session.

The researchers used a range of measures to assess the effect of training. Their primary outcome measures came from the Cambridge Automated Neuropsychological Test Battery (CANTAB) and included:

- paired-associates learning and pattern recognition memory tasks to assess visual memory;
- total errors on intra-dimensional and extra-dimensional set shifting tasks to assess rule acquisition and attentional set shifting;
- a test of spatial working memory to assess working memory and executive function; and
- a test of rapid visual information processing ("in this case a measure of how quickly and accurately targets (three separate triple-digit sequences; e.g., 2– 4–8) are detected from among distractors") to assess visual sustained attention.

The researchers also administered the Memory Functioning Questionnaire (MFQ), Memory Controllability Inventory (MCI) and 21-item Depression Anxiety and Stress Scale (DASS21) as secondary outcome measures.

Only 16 participants (8 treatment, 8 waitlist) completed the study. In terms of the CANTAB measures, the only significant difference between the trained and waitlist groups after the former's training was their score on the rapid visual information processing test which was due not only to an improvement in the scores of the treatment group following training, but unfortunately also to a decline in the waitlist group's scores on this task. There was no significant difference in scores on the MFQ, MCI or DASS21.

Limitations: all but one improvement insignificant and so does not provide strong support for Lumosity's efficacy at all; passive control only, so does not control for motivational/Hawthorne effects and not blinded; small sample sizes (although was only a pilot study).

Kpolovie (2012): [NB: Lumosity's website does not refer to this study.]

The author of this study, published in *Educational Research*, sought to compare the effectiveness of Lumosity training, 'brain-boosting food' and 'brain-boosting food supplements' on learning.

The participants were 72 boarding students from Nigeria. The author used a "randomized six-group experimental design" (p. 224) which is described as an expanded version of a Solomon four-group design to take into account two independent variables.

Their learning was assessed using an 'Experimental Learning Test' which tested content related to statistical inference, phonetics and community health. After baseline assessment (for relevant groups), all participants were provided with learning material related to the test content. Those not assigned to a Lumosity training group were instructed to study this material for 2 hours per working day for six weeks. Those assigned to undertake Lumosity cognitive training took either 30 or 60 minutes (depending on group allocation) out of the 2 hours worth of study time to do so.

The author found that students who undertook 60 minutes of daily Lumosity training showed significantly greater improvements on their Experimental Learning Test scores than those who undertook 30 minutes of daily Lumosity training, who in turn showed showed significantly greater improvements compared with the untreated control groups. (Brain-boosting food and brain-boosting food supplements also brought about significantly greater improvements on the Experimental Learning Test compared with the untreated control groups)

Limitations: only passive control groups. A number of conclusions do not seem adequately supported. For example the author claims "[r]esults of this experiment have shown overwhelmingly that the benefits of Lumosity training transfer to core cognitive abilities such as processing speed, problem solving, and task switching; and these doubtlessly make a person to learn better and forget less." This is odd, as the experiment does not appear to have involved any assessment of processing speed, problem solving or task switching.

Further studies are reported in article format, but are authored by Lumosity's creators:

Hardy, Drescher, Sarkar, Kellett, and Scanlon (2011):

This study, published in the *Mensa Research Journal*, sought to investigate the efficacy of Lumosity in healthy adults. 23 volunteers (with a mean age of 54 years) participated in the study. 14 were assigned to the training group, and 9 to the control group. The participants underwent 5 weeks of training, training daily for 20 minutes per day.

The researchers used a range of tests to assess the effect of training. These included:

- a divided visual attention test where the participant had to fixate on and identify a letter presented in the centre of the screen, and at the same time click on stimuli flashed outside the centre — the outcome being the average distance between the location of the stimuli outside the centre and the participant's mouse clicks.
- a forward visual memory span test;
- a reverse visual memory span test; and
- a letter memory test where the participant was briefly shown a string of letters of a certain length and then required to type out the string, with the length of the string increasing by one character for each correct answer.

The results indicated that, compared to the control group, the trained participants showed significant increases in the divided visual attention and forward visual memory span tests. The trained participants also showed significantly increased reverse visual memory span test results, but there was no significant group-by-time interaction for this test. No significant differences were seen for the letter memory test in either group.

<u>Tasks used:</u> 4 — Birdwatching, Speed Match, Memory Match, Monster Garden.

<u>Limitations:</u> financial interests — Hardy, Drescher, Sarkar and Scanlon all have financial interests in Lumosity; waitlist passive control only, so does not control for motivational/Hawthorne effects; the Mensa Research Journal is not itself peer-reviewed, although according to its website only accepts papers "first published in or accepted by (not just submitted to) a peer-reviewed journal, or presented at a peer-reviewed professional conference".

Some of these studies are *about* Lumosity, but do not directly support its efficacy:

<u>*Sternberg, Ballard, Katz, Doraiswamy, and Scanlon (2013):*</u>

The authors first investigated whether Lumosity users' self-reported sleep and alcohol consumption correlated with their initial performance. They found that users who reported getting larger amounts of sleep — up to 7 h per night — performed better After 7 h, however, performance began to decrease. In terms of alcohol consumption, those who reported having 1 or 2 drinks per day performed the best, with performance decreasing as intake increased from there.

Second, the authors investigated age influences improvement over the first 25 training sessions of particular cognitive tasks. They found that for all exercises, older users performed worse, but that this effect was greater for exercises involving fluid intelligence rather than any crystallised knowledge.

Finally, some studies do not appear to be reported in article format at all, and instead take the form of conference posters. These are — summarised very briefly — as follows:

<u>*Ballard, Sternberg, Hardy, and Scanlon (2012) "Training-related improvements in cognitive performance persist over time but depend on age; an online study including > 140,000 participants."*</u>

Researchers found:

(1) Long gaps in training (> 1 week) can limit performance improvements.

(2) Given the same quantity of training, young users showed greater improvement compared with older users.

(3) Gaps are more detrimental to older users' performance.

Sternberg, Hardy, and Scanlon (2013) "Cognitive performance peaks at different times of day depending on the task."

Researchers found:

(1) Baseline performance on — as well as training improvements in — working memory and attention tasks generally peaks in the morning and then declines thereafter.

(2) More elaborative/creative tasks are different. Their baseline performance is higher later in the day (i.e., afternoon and evening), and they tend to remain responsive to training throughout the day.

(3) The effect of the time of day is less noticeable in older users.

Gyurak, Ayduk & Gross (2010) "Training executive functions: emotion regulatory and affective consequences."

Researchers found:

(1) Lumosity training may improve emotional regulation as measured by eye-gaze fixations on negative regions in a picture from the International Affective Picture System.

(2) Lumosity training led to lower depressive ruminative thinking and higher self-esteem scores compared to a control group as measured 3-months post-training.

Katz, Hardy & Scanlon (2011) "Dramatic improvements in arithmetic abilities between the ages of 13 and 17 in a worldwide sample of over 440,000 adolescents and young adults playing an online game."

Researchers looked at baseline performance in the Raindrops exercise by age. They found large improvements in baseline performance levels between children aged 13 to 17, with the biggest increase between 14 and 15.

Further, the researchers' investigation into learning rates revealed that the younger children (below 15) appeared to benefit less from training on the Raindrops exercise than the older children.

Ng, Sternberg, Katz, Hardy, and Scanlon (2013) "Improving Cognitive Capacities in School-aged Children: A large scale, multi-site implementation of a web-based cognitive training program in academic settings."

Of 1204 students across 40 schools in 6 different countries, 816 (mean age 11.25) received Lumosity cognitive training, while the remaining 388 students (mean age 11.20) were placed in the no-treatment control condition. The amount of cognitive training administered to the training group varied depending on teacher needs and preference. Students in the training group could also use the software at home if they had a computer and internet access. Based on data from Lumosity's BPT taken pre- and post-intervention, researchers found:

(1) The training group's Brain Performance Test (BPT) scores improved significantly more than the control group's did.

(2) There is a positive correlation between hours spent training and improvement on the BPT.

Sternberg, Hardy, Katz, Ballard, and Scanlon (2012) "Preliminary findings of transfer from cognitive training to a repeatable, dynamically generated assessment."

This poster details preliminary findings into the reliability of the Lumosity Brain Performance Test (BPT). The researchers claimed:

(1) Test-retest reliability is "comparable to validated brief intelligence tests, such as the Wechsler Abbreviated Scale of Intelligence (FSIQ-2, 15 minute version, r = 0.88)."

(2) BPT scores change with age — in a similar way to what one would expect of scores on a test of fluid intelligence.

(3) Correlations between the different subtests range from 0.28 to 0.72. They argue this means the subtests reflect distinct cognitive abilities.

(4) There is a positive correlation between hours spent training and improvement on the BPT.

Evidence against efficacy:

Shute, Ventura, and Ke (2015):

This study, published in *Computers & Education*, sought to compare the effect on problem solving skills, spatial skills, and persistence of playing eight hours of the videogame *Portal 2* with completing 8 hours of Lumosity cognitive training.

77 undergraduates (aged 18–22) participated in the study. 42 were randomly allocated to play *Portal 2*, and 35 to train using Lumosity. Gameplay/training was split across three sessions. Each lasted three hours, with participants undertaking eight hours worth of play or training (time was taken from the first session for baseline assessment). Participants also had to attend one further one-hour session for post-intervention reassessment.

The researchers used a battery of online tests for baseline and post-intervention cognitive assessment. This included:

- problem solving measures — Raven's progressive matrices (RPM), a verbal insight test and the remote-association test (RAT);
- spatial cognition measures — mental rotation test (MRT), spatial orientation test (SOT), virtual spatial navigation assessment (VSNA); and
- persistence measures — these differed at baseline and post-intervention testing. At baseline testing, a persistence self-report survey was administered. At post-intervention testing, a picture comparison task was administered. This involved the user identifying four differences in two pictures in up to 180s, or skipping that set of pictures if they could not do so, the key measurement being the time spent on impossible sets of pictures. The self-report survey was used as a covariate for the picture comparison task.

When comparing post-intervention scores between groups, the researchers found significantly different results in favour of *Portal 2* in performance on the insight test as well as the MRT and VSNA, even controlling for player enjoyment. When comparing within-condition baseline—post-intervention performance, there were no significant gains either for the Lumosity or *Portal 2* group across any of the problem solving measures. There were further no significant gains on any of the spatial cognition measures for the Lumosity group. *Portal 2* players did, however, show significant improvements on the MRT and VSNA tests.

Limitations: small sample size and so may lack power; low reliability of tests used; use of one-tailed statistical tests.

Note the general limitations of studies supporting Lumosity's effectiveness as discussed above — particularly the lack of an active control group. Further note that the studies do not relate to developmental learning disabilities, and that not all Lumosity exercises may be as effective as others — the literature seems to use only a few games of those available.

Price:

Individual, Monthly: USD 11.95 /month.

Individual, Yearly: USD 5.00 /month.

Individual, Two Year: USD 3.75 /month.

Individual, Lifetime: USD 299.95.

Group package (up to 5 members), Yearly: USD 8.33 /month.

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L Orton-Gillingham

Website / for more information see:

http://www.ortonacademy.org/index.php

What it involves:

An instructional, generally one-on-one approach (though it can also be done in small groups and has been used in classrooms). The main purpose of the approach is to assist the participant in becoming a competent reader/writer and an independent learner. It involves the following characteristics (note: details below were obtained from http://www.ortonacademy.org/approach.php):

- *Personalised*

  Involves recognising the individual needs of the learner and identifying whether there are additional difficulties that may complicate learning e.g. comorbid conditions.

- *Multisensory*

  Multisensory methods are used by the instructor to convey content. The instructor also demonstrates how students can engage in multisensory learning. The student learns content through auditory, visual and kinaesthetic elements, i.e. listening, reading, speaking and writing. This is believed to enhance memory storage and recall.

- *Diagnostic and Prescriptive*

  Diagnostic as the instructor continuously monitors the verbal, nonverbal and written responses of the student to identify both the student's problems and their progress. This information in turn informs subsequent sessions.

  Prescriptive as the sessions will contain instructional elements that focus on resolving the student's difficulties and improving on their progress from previous sessions.

- *Direct Instruction*

  Lesson formats are used to ensure that the student understands what needs to be learned, why it needs to be learned and how it will be learned.

- *Systematic Phonics*

  The alphabet principle is stressed during initial stages of reading development, particularly sound/symbol associations.

- *Applied Linguistics*

  Applied linguistics are drawn upon in initial decoding and encoding stages of reading and writing as well as in advanced stages involving syllabic, morphemic, sematic and grammatical structures of language and the English writing system.

- *Linguistic Competence*

  Language patterns that determine word order and sentence structure as well as the meaning of words and phrases are stressed. More advanced work involves recognising the various forms that characterise the common literary forms employed by writers

- *Systematic and Structured*

  Information is presented in an ordered way that indicates the relationship between the material being taught and previously taught information. Sound/symbol associations, linguistic rules and generalisations are introduced in a linguistically logical and understandable order.

- *Sequential, Incremental and Cumulative*

  As linguistic skills are mastered, learning progresses from simple and well-learned material to more complex information. Firstly, students read and write sounds in isolation. This is followed by the blending of sounds into syllables and words. Elements of language such as consonants, vowels, digraphs, blends and diphthongs are learnt in an orderly manner, followed by more advanced structural elements such as syllable types, roots and affixes. Previously learnt material is continuously revised until students achieve mastery. Vocabulary, sentence structure, composition and reading comprehension are addressed in a similar structured, sequential and cumulative manner.

- *Continuous Feedback and Positive Reinforcement*

  This enables the development of greater self-confidence and a close teacher-student relationship.

- *Cognitive Approach*

  Students understand the reasons for what they are learning, by learning the history and structural generalisations and rules of the English language. They also learn the reasons for their learning strategies and how to apply the necessary language knowledge for competent reading and writing.

- *Emotionally Sound*

  Success in reading/writing/spelling increases self-confidence and motivation for learning.

The Orton-Gillingham approach has several adaptations, including Alphabetic Phonics, Wilson Reading System, Herman Method, The Spalding Method, The Slingerland Approach (discussed separately in this report) and Project Read. The studies discussed below focus on Orton-Gillingham as well as Orton-Gillingham-based training and interventions. Although the programmes vary slightly, the core multisensory, systematic, sequential, phonics-based approach is a consistent aspect of all adaptations.

What claims does the company make / what does the programme target?

The programme is aimed primarily at individuals with dyslexia, with a focus on improving reading, spelling and writing difficulties. However, the approach has also been adapted for use with students who have difficulties with mathematics (e.g. dyscalculia). It is appropriate for all school-aged children as well as adults, though early intervention is recommended.

Evidence for efficacy:

Litcher & Roberge (1979):

This article discusses the results of the High Risk Experimental Project, which involved comparing the reading-related achievement of primary school children at risk for reading problems following either Orton-Gillingham instruction (n = 20) or standard school curriculum teaching (n = 20). Students were taught the Orton-Gillingham or standard reading and language instruction 3 hours per day. The Metropolitan Achievement Test (word knowledge, word analysis, reading and total reading subtests) and the vocabulary and comprehension subtests of the Gates MacGinitie Reading Test were used to assess children's reading-related skills. Assessments were carried out at the end of each year over the course of three years.

t-tests revealed that at the conclusion of each year, the Orton-Gillingham group were superior to the control group on all measures that were assessed.

Limitations: authors do not mention whether any pre-test measures were taken or controlled for, therefore it is unclear whether there were any differences in reading-related skills between the two groups prior to training. Many t-tests were used without any correction for multiple comparisons. No alternative treatment group. Initial selection of subjects was based on apparent difficulty in either the visual, auditory or motor area. This may have resulted in a rather heterogeneous group, in terms of the sensory difficulties that they are experiencing. A more specific selection criteria would have been better. The article itself notes that variables associated with the experimental teachers (e.g. bias about the student's performance as a result of being in the treatment group) could have affected the study's outcome.

Stoner (1991):

This study compared the performance of students who underwent standard basal reading instruction (control group) to that of students who participated in a classroom adaptation of the Orton-Gillingham instruction, known as Project Read. 130 first graders, 70 second graders and 83 third graders, all at risk for reading problems, took part in the study. Participants' total reading and subtest (word reading skills, word reading and reading comprehension) scores of the Stanford Achievement Tests reading sections were measured at the end of each school year.

MANOVA and ANOVA results revealed that the first graders in the Project Read group obtained greater scores on all measures relative to first graders in the control group. However, no significant differences were observed for second and third graders.

Additional analyses were conducted on a subtest of participants, controlling for the teacher variable (this analysis only included participants whose teachers taught in both the basal programme and Project Read). Results for first graders were consistent with the original results. However, with this analysis, second graders in the control group obtained greater scores on all measures relative to the Project Read second graders. The authors argue that the reduction in sample size with second graders (n < 15 for both groups) "limits interpretations of this data". No significant differences were observed with third grade students in this teacher-variable-controlled analysis.

Limitations: study does not mention whether participants were measured prior to receiving either basal reading or Orton-Gillingham-based reading instruction, therefore we do not know whether there were any differences in reading measures between the two groups. Results seem very mixed, especially when considering the data for the second graders. No alternative treatment group. Possibility that teacher bias may have affected results. No mention of the protocol used to implement Project Read or the basal reading instruction, i.e. how many hours per day, how many days per week.

Oakland, Black, Stanford, Nussbaum and Balise (1998):

In this study, the efficacy of teacher- and video-directed versions of the Orton-Gillingham-based Dyslexia Training Program (DTP) were compared to that of traditional reading instruction (control group). In total, 22 students received DTP (either teacher or video-directed) and 26 students were in the control group. DTP students underwent instruction for 1 hour/day, 5 days/week for 10 months/year over the course of 2 years. The Reading Comprehension subtest of the Gates-MacGinitie Reading Test, the Word Recognition and Spelling subtests of the Wide Range Achievement Test-Revised and the monosyllabic and polysyllabic phonological transfer indices of the Decoding Skills Test were administered to all participants prior to study commencement, and at the end of Year 1 and Year 2.

Preliminary results revealed that there were no significant differences between the teacher-directed and video-directed DTP groups in any of the reading-related measures, therefore subsequent analyses combined these two groups to form a single DTP group. Comparing this combined DTP and control group, the DTP students made significant progress in reading comprehension over the 2 years, whereas the control group did not. For word recognition and polysyllabic phonological decoding, the DTP group initially had poorer scores than the control group, but outperformed them at the end of the 2 years; the control group showed little improvement. Both groups showed comparable improvement on monosyllabic phonological decoding over the 2 year period. No significant effects were observed for the spelling measure, with both groups showing little improvement over the 2 year period.

Limitations: no alternative treatment group: the standard reading instruction received by participants in the control group was what was generally provided in their own school. It is unclear whether schools that the control participants went to differed in the reading instruction provided. If so, it is possible that the control group may have been rather heterogeneous in terms of the reading instructions received. 15 DTP students and 10 control students were receiving supplementary reading assistance which was not controlled for. This may have confounded results.

Hook, Macaruso, and Jones (2001): *[NB: this study has also been discussed in the FFW notes.]*

Hook et al. compared the efficacy of the Fast ForWord (FFW) Language and Orton-Gillingham programmes on the language and reading abilities of 7 to 12 year olds with reading difficulties. Children in the FFW group (n = 11) completed 5 of 7 FFW Language exercises for 100 mins overall, 5 days a week for 2 months, while children in the Orton-Gillingham (OG) group (n = 9) received a one-to-one intervention method for one hour a day, 5 days a week for 5 months. Behavioural measures (Woodcock Reading Mastery Test – Revised Word Attack and Word Identification; Lindamood Auditory Conceptualisation Test for phonemic awareness) were collected prior to and following training.

Results indicated that while both groups improved on phonemic awareness following training, this improvement was significantly greater for the Orton-Gillingham group. Furthermore, the OG group made significant gains on the Word Attack measure, whereas the FFW group made no reading-related gains.

Limitations: participant recruitment differed for the OG and FFW groups. Children in the OG were enrolled in a summer school for children with reading difficulties, whereas the FFW participants were those who responded to flyers advertising the study. While the groups did not significantly differ on IQ, age, phonological awareness and reading abilities, it is possible that the summer school may have provided the OG children with a more structured and well-controlled environment than the FFW group, which may have contributed to the efficacy of the intervention. Long-term and additional measures were collected for the FFW group (e.g. speaking and syntax components of spoken language) but not for the Orton-Gillingham group. Consequently, we cannot comment on the effect of Orton-Gillingham instruction on these additional measures, or its long-term efficacy.

Joshi, Dahlgren and Boulware-Gooden (2002):

This study investigated the efficacy of the Orton-Gillingham-based Language Basics: Elementary programme (n = 24) relative to the Houghton-Mifflin Basal Reading Programme (control group; n = 32) in improving the reading-related skills of first grade students. Students were assessed on phonological awareness (Test of Phonological Awareness), decoding (Word Attack subtest of the Woodcock Reading Mastery Test-Revised) and reading comprehension (comprehension part of the Gates-MacGinitie Reading Test) prior to and following training.

Comparing gain scores from pre to post-test, results revealed that the Language Basics group showed significantly greater gains on all three measures relative to the control group. Additionally, the Language Basics group showed a significant increase on all measures from pre to post-test, but the control group children only made statistically significant gains on reading comprehension.

Limitations: initially 40 participants had been selected to participate in the Language Basics programme, but there was loss in the number of students due to children being moved out of the school district; gain scores have been criticised for having unknown reliability (Hyatt, 2007).

Evidence against efficacy:

Chandler, Munday, Tunnell, and Windham (1993):

Chandler et al. compared the efficacy of an Orton-Gillingham-based Alphabetic Phonics programme to that of a traditional developmental reading course in 43 community college students. The traditional reading method focused on comprehension skills, reading efficacy, study skills and strategies for test-taking. The study design was quasi-experimental, with students participating in either programme over the course of one semester.

The study found that the group who underwent traditional reading instruction had significantly better reading performance (Nelson-Denny Reading Test) than students in the Orton-Gillingham-based group. The Alphabetic Phonics group did improve on reading performance from pre-test to post-test, however the traditional developmental reading course appeared to be more effective.

Limitations: we were not able to access the original article, and so details on the study were obtained from the review article by Ritchey and Goeke (2006). Consequently, we cannot comment on whether the methodology used by Chandler et al. was sound. The study did use a quasi-experimental design and it is unclear whether there were significant differences in reading performance between the two groups and, if so, whether this was controlled for in the analyses.

Foorman et al. (1997):

114 second and third grade students with reading disabilities underwent Orton-Gillingham-based synthetic phonics instruction, analytic phonics instruction or sight word reading instruction for 60 mins/day across the school year. Students were measured prior to taking part in reading instruction, four times during the course of the intervention period and again at the end of the school year (once the intervention was complete). Children were measured on phonological processing, orthographic processing and word reading (Woodcock Johnson Psychoeducational Battery-Revised).

Growth curve analysis was used to analyse the results. When controlling for age, the synthetic phonics instruction group significantly outperformed the analytic phonics group on all three measures, although this was no longer significant once demographic variables were controlled for. The synthetic phonics group also outperformed the sight word instruction group on phonological processing and word reading; however when demographic variables were controlled for, the synthetic group was superior to the sight word reading group for phonological processing only.

Limitations: did not randomly assign students to the treatment groups; the synthetic phonics group had higher initial decoding scores (measured using the Woodcock Johnson Psychoeducational Battery-Revised Basic Reading Cluster) than the other two groups — there is no mention of whether this was controlled for in analyses.

Ritchey and Goeke (2006):

Ritchey and Goeke reviewed 12 studies investigating Orton-Gillingham instruction, including those discussed above and noted that there was a need for thorough, scientifically-based research for Orton-Gillingham. Specifically, the article notes that there are several methodological issues present in many of the Orton-Gillingham studies:

- primarily quasi-experimental designs;
- many have sample sizes <50;
- several older studies;
- more recent articles also do not report some information: details regarding procedures used to ensure that treatment groups were comparable in quasi-experimental designs; treatment fidelity; technical characteristics of dependent measures; details on training provided to teachers/instructors.

The authors advise caution when generalising any of the studies' results. They note that "differences in study participants, settings, location, program type, instruction time, the Orton-Gillingham instructional program and implementation, and outcome measures must be considered when evaluating this research."

Price:

The cost of Orton-Gillingham training varies depending on the provider and the type of Orton-Gillingham-based approach used. Only the fees for the training and certification provided by the Institute for Multi-Sensory Education (IMSE) will be described below. The IMSE offers two levels of Orton-Gillingham certification for individuals who have a Bachelor's degree as well as a teaching/other preapproved educational licensure:

Level 1 Certification:

- Coursework: 30 hours for comprehensive training; 69 hours for advanced training.
- Practicum: 45 (60 mins) lessons or 60 (45 mins) lessons + 5 observations.

- Fees: $975 course fee; $75 application fee (one time); $200/hour + travel expenses for practicum observation fee; $75 Annual renewal fee.

Level 2 Certification — Specialist:

- If the individual has received Level 1 comprehensive training, then they will receive Advanced training, and vice versa. Both comprehensive and advanced practicums must be completed for Level 2 certification.
- Fees: $975 course fee; $75 application fee (one time); $200/hour + travel expenses for practicum observation fee; $75 Annual renewal fee.

For more details see http://www.orton-gillingham.com/training/certification/.

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M The Slingerland Approach, as used in New Zealand by The Learning Key

Website / for more information see:

http://www.thelearningkey.org/

http://slingerland.org/

What it involves:

The Slingerland Approach is an adaptation of the Orton-Gillingham method which can be used in classroom situations, although can also be used in individual tutoring situations (Brigs & Clark, 1997). Lessons are multisensory, incorporating auditory, visual, and kinaesthetic elements. The programme focuses on phonics, and includes instruction in:

- the alphabetic principle (the fact there is a relationship between alphabet letters and spoken sounds);
- blending letters to read written words and spell words;
- suffixes, prefixes, and irregular phonetic rules; and
- vocabulary.

Instruction begins with a single unit and becomes more complex. Exercises may involve naming written letters, saying their sounds, drawing letters/suffixes/prefixes/phonemes/words in the air with fingers and/or writing these down, finger-tapping syllables, and tracing letters in trays of sand. Spelling from dictation is also used. Students generally undergo Slingerland teaching for two years.

Videos of Slingerland instruction in progress can be viewed at:

https://www.youtube.com/watch?v=nQiQ71wepJg

https://www.youtube.com/watch?v=FDZtKVsoFgc

What claims does the company make / what does the programme target?

On the Slingerland Institute's (n.d.-a) website, it claims that:

(1) The intervention can be preventative if students with difficulties are identified before normal reading instruction takes place.

(2) However, there are considerable individual differences in dyslexia. It is therefore difficult to predict the rate and degree of success of Slingerland instruction. Some students may show considerable improvement and become overall very comfortable with reading and writing; others might improve in some areas but still show deficits in others.

(3) Factors that can influence the rate and degree of success include: severity of dyslexia pre-intervention; age of identification; motivation; individual teacher quality.

Evidence for efficacy:

Encouragingly, the Slingerland Approach systematically and explicitly (although not exclusively) targets phonetic rules, difficulty with which is generally thought to be the underlying cause of dyslexia (Shaywitz & Shaywitz, 2005). Meta-analysis has revealed systematic phonics instruction helps students to learn to read, is more effective than whole language approaches, and is more effective if begun early (Ehri, Nunes, Stahl, & Willows, 2001).

However, we could access only one study in a peer-reviewed journal that directly investigated its use:

Lovitt & DeMier (1984):

- Compared the efficacy of two competing reading remediation programmes — the Slingerland and Sullivan (a more individualised programme) approaches in learning disabled children.
- The first group (n = 7) received Slingerland instruction. The second (n = 7) received Sullivan instruction.

- The researchers used ten before and after measures:
  - the Metropolitan Achievement Test (MAT)
  - the Slingerland Screening Test (SST)
  - Lippincott measures:
    - reading passages orally
    - saying facts from the passages
    - answering comprehension questions from the passages
    - reading word lists
  - Ginn 360 passages
  - Phonics measures – students had to say sounds from a sheet of written:
    - letters
    - consonant blends
    - consonant vowel consonant (CVC) words
- Improvements were noted on most measures for both groups. On some measures (notably in terms of correct response rates, and the SST generally), the Slingerland group showed greater improvements. On others (notably in terms of a reduction in incorrect responses, and the MAT generally), the Sullivan group improved more.
- Authors concluded both methods equally effective.

Limitations: no (reported) significance tests; no control group; group assignment not fully random.

The Slingerland Institute (n.d.-b) mentions a number of further studies in its document 'Slingerland Research', but generally seem to be unpublished dissertations/theses. A full reference list is unfortunately not provided, so it is difficult to access and assess many of these.

Evidence against efficacy:

There is a general lack of research into the Slingerland method. The Slingerland Institute (n.d.-c, para. 3) does claim that "[c]urrent Slingerland research projects are in process and results will be forthcoming". There are, however, other studies investigating the efficacy of Orton-Gillingham methods more generally — see Orton-Gillingham's section in this report.

Price:

Varies. Costs differ first depending on whether a parent is seeking individual tutoring, or whether a school is looking to train its teachers in the Slingerland Approach.

Where a parent is seeking individual tutoring, the Slingerland Institute recommends at least 2 sessions per week.

Where a school is looking to train its teachers in the Slingerland Approach, it must decide whether it wants them to qualify as "Slingerland Trained" or to progress to being fully "Certified Slingerland" teachers. A Slingerland Trained teacher is one who has completed at least one comprehensive course of 133 hours of instruction that includes a practicum. The requirements for becoming a Certified Slingerland teacher are more stringent, and include:

- completing the Introductory and Second Level Comprehensive Courses;
  - requires 266 hours of coursework, including 60 hours of practicum

   - requires studying "the history and etiology of dyslexia, comprehensive instruction in the system and structure of the English language (morphology and phonology), the science of the reading brain, vocabulary, assessment and specific Slingerland techniques in the development of daily lessons".
- holding a Bachelor's Degree or higher;
- 2 years of experience using the Slingerland Approach; and
- holding current membership with the Slingerland Institute.

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N Steps

Website / for more information see:

http://learningstaircase.co.nz/why-steps/

What it involves:

Steps is a computer-game programme that uses a structured, multi-sensory literacy approach based on educational principles. The programme can be completed at home (ideally by older learners or parents), through tutors, tutoring centres or at school. The literacy areas covered by the programme include phonological awareness, phonic knowledge, fluency, vocabulary and comprehension. The website claims that all activities used in Steps, described below, are cumulative and based on research about literacy acquisition and how the brain works. Note that the descriptions below were obtained from the Steps website.

Wordlist Activities: Word Recognition

The words used in the wordlist activities depend on a range of different wordlists available through Steps, but can also include individualised wordlists. These Wordlist Activities are intended to be done in the order described below.

- *Find the Word*: a target word is said aurally, and the learner must find the word in a group of words scattered across the screen. Targets word recognition, decoding skills and familiarisation with vocabulary.

- *Choose the Word*: a sentence is presented visually and aurally with a missing word. The learner must select the appropriate word from several words to complete the sentence. Targets learning how to use the word in context and vocabulary.
- *Word Flash*: a word flashes on screen (flash can either be slow, medium or fast). The learner must select the flashed word from a list of words. Targets instant visual recognition and allegedly activates the occipito-temporal area.
- *Sentence Builder*: words randomly scattered across the screen have to be sequenced in an order that makes sense. Targets using the word in context, understanding sentence structure and sequencing.
- *Word Search*: the learner has to find embedded words in a word search grid. Words are only presented horizontally. Targets visual discrimination, pattern recognition and an awareness of word structure.

Wordlist Activities: Spelling

- *Spelling*: the learner must spell out a word while it is briefly on screen. The word then disappears and the learner has to type out the word. If a mistake is made, the computer shows the learner where they went wrong (i.e. what letters were incorrect), and the learner has another attempt at spelling out the word. Teaches the spelling of the word, visual sequencing and an awareness of phonic structure.
- *Chunks*: the learner hears a word and must choose the correct onset and rime from several possibilities. Targets an awareness of onset plus rime, an awareness of initial sounds/blends, blending and analogical transfer (awareness of and ability to use patterns in language).
- *Drop*: the learner hears a word. The letters of the word then appear in random order, and the learner must place them in the correct space/location within the word. The completed word is then dragged and placed on a visual presentation of the target word from a list of several words located to the left of the screen. Targets familiarity with spelling, awareness of phonic pattern, auditory and visual sequencing, and the ability to visualise words.
- *Spelling Test*: provides practice with spelling words and checks spelling ability and familiarisation with words in the list. The learner gets a bronze, silver or gold medal depending on their spelling accuracy.

Wordlist Activities: Phonics

- *Sound Tiles*: targets phonemic awareness, auditory sequencing, segmentation/blending and phonic knowledge.
- *Sound Boxes*: each phoneme from a word has to be sorted into separate boxes. Targets phonemic awareness, auditory sequencing, segmentation/blending and phonic knowledge.
- *Initial Sounds*: targets awareness of onset plus rime, phoneme transposition and analogical transfer.

Wordlist Activities: Memory

- *Visual Memory*: a matching game where the learner must match words in as few clicks as possible. Targets visual and spatial memory, focus and concentration, and word recognition.

- *Word Grid*: the learner first hears one target word. Several words then appear on a grid and the learner must click on the target word. If this is done correctly, the learner will then hear two words and then select those words in the correct order from the grid. The number of target words increases by one with each correct response. Targets auditory sequential memory, focus and concentration, working memory, listening skills and the use of auditory rehearsal techniques.
- *Word Memory*: targets auditory sequential memory, focus and concentration, working memory, listening skills and spelling of the word.

Wordlist Activities: Additional

- *Definitions*: targets vocabulary, verbal reasoning and comprehension.
- *Homophones*: targets an understanding of homophones, word recognition and vocabulary.

Games

- *Pop the Balloon*: 26 holes are lined up, each corresponding to a letter of the alphabet. Balloons, sometimes in clusters, come out of the holes, with letters on it corresponding to the hole that it came out of. The learner has to shoot the balloon(s) by pressing the letter on the balloon (clusters of balloons can be shot by just pressing one of the letters from the balloon cluster). Occasionally a rabbit will appear from one of the holes, and the learner must figure out what letter corresponds to the hole the rabbit came out of and shoot it by pressing that letter. The game can also be done without letters on the balloon. Targets spatial awareness of the alphabet, alphabet sequencing, ability to "count on", keyboard knowledge and quick thinking.
- *Blocks*: essentially Tetris, but the speed can be slowed. Targets spatial awareness, fine motor coordination and quick thinking.
- *Vowel Sounds*: a word is presented with the vowel missing. Vowels pass along the screen on a conveyor belt, and the learner must shoot the missing vowel. This task automatically adapts to the level of the learner. Targets phonic knowledge and an awareness of medial vowel sounds.
- *Clear the Skies*: the game uses a 3D design and involves the learner flying an in airplane. Words are presented with a missing letter, and the learner must shoot balloons with the missing letter. Targets phonic knowledge, an awareness of medial vowel sounds and spatial awareness.
- *Fireworks*: letters come along the screen, requiring the learner to track from left to right. The learner must click on a target letter within a particular timeframe. At the end of the timeframe, fireworks go off. Letters classified as targets can be determined by the learner or a trainer prior to starting the game, and the speed and timeframe can be customised. The activity can also be completed using numbers or words. Targets letter recognition (reversals, etc.), directionality, tracking and visual discrimination.
- *Snap*: cards with shapes which can vary in form or colour are presented from two decks. The learner must click to "snap" when the cards match. Targets perceptual organisation, quick thinking and visual recognition.
- *Vowel Ladder*: the learner plays against the computer, where both the individual and the computer have a "ladder" of letters with missing vowel sounds in between

(e.g. "r ...m"). The learner must then select vowel letters and place them in the ladder to form a word (e.g. place "I" between the r and m to form "rim"). The vowel sound and speech can be customised. Targets phonic knowledge, phonemic awareness, medial vowel sounds and initial/end blends.

- *Hangman*: like the classic Hangman game. Targets an understanding of word structure and phonic patterns, as well as spelling.
- *Four in a Row*: the learner can play against a second player or the computer in this game. A grid is presented, with each column numbered. During each player's turn, the individual "rolls" a virtual dice and then selects a cell in the grid from the numbered column corresponding to the number rolled from the dice. They are then presented with a fill-in-the-blank question, where they must select a word from a selection that completes the sentence. Players must try to get four cells in a row. The game can be done with a vocabulary or homophones option. Targets strategic thinking and spelling/homophones knowledge.

General: Alphabet Section

- *Alphabet — Reference*: the learner is showed how to form a letter, and is told the letter name and its sound. Teaches letter formation, letter sounds, letter names, different sounds of a letter and phonemic awareness (initial sounds).
- *Letter Names*: targets the development of letter names, letter recognition and lower and upper case knowledge.
- *Letter Sounds*: targets the development of letter names, letter recognition and lower and upper case knowledge.
- *Letter Chunks*: teaches alphabet sequencing.
- *Reversals*: this task is for learning how to avoid reversals with letters that are commonly mixed up e.g. b and d, p and q. If the learner struggles with distinguishing b and d, then the task involves b and d letters scattered across the screen which the learner must sort into the appropriate "b" or "d" container. Targets visual discrimination and directionality.
- *Alphabet Order*: the learner has to track left to right along a word grid, clicking letters as they come up in alphabetical order (so will first have to find "a", then "b" then "c" along the grid and so on). Targets visual discrimination, alphabet sequencing and tracking.

General: Number Section

- *Numbers — Digits*: targets number recognition and the recognition of number words.
- *Number Chunks*: targets number sequencing.
- *Number Grid (Levels 1 & 2)*: targets auditory sequential memory, focus and concentration and the use of auditory rehearsal strategies.
- *Number Grid (Level 3)*: As above, plus working memory.
- *Reversals*: the learner can choose up to three numbers that they struggle with. The numbers are scattered across the screen, either in reversed or correct form. Reversed numbers go into the wrong container, marked "x", and the numbers in correct form go into their respective numbered containers. Targets visual discrimination, number reversals and directionality.

General: Spatial Section

- *Directions:* teaches left/right automaticity, spatial concepts (up/down), colour/shape awareness and the ability to process several concepts at once.
- *Perception:* targets spatial awareness and perceptual organisation. Requires the ability to rotate shapes and make spatial judgements.

General: Spelling Section

- *Initial Blends*: targets phonic knowledge, auditory discrimination, phonemic awareness and blending.
- *Endings, -k, -ke, -ck*: teaches phonic knowledge, an understanding of the silent –e pattern, and the rule "-ck" after short vowel sound, "-k" after long vowel sound.
- *Silent –e*: targets an understanding of the silent –e rule, auditory discrimination of long/short vowel sounds and an understanding of visual pattern.
- *Short Vowels*: targets an understanding of short vowel patterns, auditory discrimination of short vowel sounds and an understanding of visual patterns.

General: Useful Stuff

- Colours: teaches colour recognition and colour words.
- Days: teaches sequencing days of the week and auditory sequencing skills.
- Months: teaches sequencing months of the year and auditory sequencing skills.

Spelling Test

- *Spelling Test*: Schonell spelling test – used for pre-test or post-test. Gives a record of errors.

Participants in the Steps programme are assessed on their literacy level prior to taking part in the programme. Steps then advises the individuals on where they can start in the course, based on their literacy ability.

The programme is said to be customisable, such that schools and workplaces can adapt the programme to suit the school curriculum or workplace needs by altering the wordlists used or creating their own wordlists. There are also additional Steps resources available to accompany the programme, such as workbook-based literacy courses, games for school or home use and printable worksheets with word lists/flash cards, word grid games and handwriting tasks. The Steps website also notes that the programme is also currently working on developing a Maori course, but Steps' customisable nature means that Maori words can be added to wordlists.

What claims does the company make / what does the programme target?

Steps is said to be suitable for individuals 5 years and over, including adults and English language learners, and claims to help those with dyslexia and ADHD. The programme specifically targets all aspects of literacy, including vocabulary, comprehension and verbal reasoning. The courses can range from a pre-literate level to a spelling level of 13 years plus, but can be customised up to a university level.

The programme specifically targets phonological awareness, phonic knowledge, fluency, vocabulary, comprehension, visual perception, sequencing, memory and motor development. Steps claims to help children read words confidently, recognise words instantly, put words into context, spell words and break them down into their individual phonemes, blend words, define words and type/write words. The programme also aims to improve memory, specifically visual memory, auditory sequential memory and working memory.

Evidence for efficacy:

The tasks in Steps are all informed by research (see http://learningstaircase.co.nz/why-steps/steps-research/ and http://learningstaircase.co.nz/why-steps/steps-and-dyslexia/ for greater details and references). While it is commendable that the programme takes into account research on literacy and dyslexia, there are unfortunately no peer-reviewed studies evaluating the programme's efficacy. Consequently, we cannot comment on whether or not the programme appears to be an effective intervention for language difficulties.

Price:

A Stage 1 training course in Steps costs $195. This course is aimed at teachers, RTLB's, teacher aides or tutors who are interested in Steps.

O The Tomatis Method for Auditory Retraining

Website / for more information see:

http://www.tomatis.com/ and http://www.tomatisassociation.org/.

What it involves:

Alfred Tomatis believed that the ear's function during foetal gestation was to "energize the developing nervous system" (Tomatis Developpement SA, n.d.-a, "Why use filtered music?"). As such, Tomatis therapy is developmental in nature, and is designed to remediate a disrupted ability to analyse sensory messages (sounds in particular). Unlike most other cognitive remediation programmes, however, Tomatis therapy focuses in particular on "two muscles located in the middle ear whose role is to enable the precise and harmonious integration of acoustic information into the inner ear, and from there to the brain" (Tomatis Colombia, n.d.) as opposed to the brain itself.

In practice, the Tomatis method involves filtering music (in most cases Mozart and Gregorian chant) and speech through a device known as an 'Electronic Ear' and then listening to this through headphones, attached to which is a 'bone conductor'. The Electronic Ear "attenuates low frequencies and amplifies higher frequencies that fall within the language area which allows the subject to gradually focus listening on the language frequencies" (Neysmith-Roy, 2001, p. 20). The bone conductor permits "the sounds to be heard through bone vibration as well as the usual air conduction" (p. 20).

There are two main types of therapy (Neysmith-Roy, 2001):

(1) *Passive*, in which the patient listens (using headphones and bone conductor) to classical music (Mozart) and recordings of their mother's voice filtered through the Electronic Ear.

(2) *Active*: in this phase, the patient repeats or reads words into a microphone, allowing their speech to be filtered through the Electronic Ear and played back to them through their headphones and bone conductor. This lets the patient hear his/her own voice with the 'correct' frequencies amplified, and gradually introduce these 'correct' frequencies into their speech (which, once treatment ends, continues to

reinforce their listening). As the programme progresses, treatment progressively focusses more on the right ear "which according to Tomatis theory and practice is better positioned to ensure good self-listening and clear articulation of vocal emission." (p. 20).

Treatment requires about 90 hours (Ross-Swain, 2007). One provider (LearningSmart, n.d.) indicates treatment takes places in blocks of 10-13 days for up to two hours each day. These are referred to as 'Intensives'. Intensives are separated by rest periods whose duration can vary between three and eight weeks (Neysmith-Roy, 2001).

What claims does the company make / what does the programme target?

On its website Tomatis (n.d.-b) claims its product "operates on the plasticity of the neural circuits involved in the decoding and analysis of sounds, as well as on those involved in motricity, balance, and coordination. As such, the Tomatis® Method can help children develop compensatory strategies to deal with and manage their learning difficulties and language disorders. The Tomatis® Method does not eliminate these problems altogether, but at least helps the person manage them better and thus effectively overcome them."

More specifically, Tomatis (n.d.-b) claims its product can improve:

- attention disorders, by improving selective attention;
- emotional disorders and stress, by acting on the prefrontal cortex, limbic system and cochlea;
- communication disorders;
- psychomotor difficulties, by improving function of the vestibule;
- pervasive developmental disorders, by improving functioning of mirror neurons; and
- one's ability to learn a foreign language, the voice and musicality generally, foetal development, and one's overall personal development and well-being.

Note, however, that Tomatis himself (1991, discussed in Neysmith-Roy, 2001) disclaimed that the Tomatis method could only appreciably improve the quality of life for approximately 60% of children with autism, and that it should not be marketed as a cure.

Tomatis is not entirely clear about the neural correlates of any improvements brought about by its programme. Gerritsen (2009) suggests that improvements may be due to increased myelination of neurons in auditory circuits improving their speed of conduction and processing, and to some kind of increased sensory integration or balance between sympathetic and para-sympathetic nervous systems.

Evidence for efficacy:

A number of studies are provided in support of the efficacy of the Tomatis intervention (Gerritsen, 2009; Tomatis Association, n.d.; Tomatis Developpement SA, n.d.-c;) in various clinical populations. Unfortunately, many of these are older unpublished theses or conference papers which were not readily available to us. Reported below is the available peer-reviewed research on the Tomatis programme, some of which (e.g., the Gilmor, 1999 meta-analysis) describes or analyses the unpublished data.

Gillis & Sidlauskas (1978):

Group: ten dyslexic children (mean age 8.1 years; 9 males).

Method: pre-treatment/post-treatment score comparison.

This study, published in *Neuropsychologia*, involved comparing the total number of words ten dyslexic children could read in five minute periods under various auditory feedback conditions, brought about using Tomatis equipment to modulate ear laterality and frequency. The conditions were:

Condition	Auditory Feedback to Right Ear (%)	Auditory Feedback to Left Ear (%)	Electronic Ear Frequency Modification
R + F	100	10	Yes
R	100	10	No
F	100	100	Yes
C	100	100	No

Testing was conducted twice weekly over a four-month period. On each testing occasion the children's reading was recorded under all four conditions, randomly ordered using a computer-generated schedule.

The researchers found a significant main effect for condition, with analysis using Scheffe's test revealing a significant difference ($p < 0.01$) between the right ear only (R) and control condition (C). They concluded that these results supported the theory that dyslexic children show abnormal auditory lateralisation and fail to make use of a 'right ear advantage'.

<u>Limitations:</u> this study does not provide strong support for or against the efficacy of the Tomatis method itself because although Tomatis equipment was used, what was being assessed was not closely in line with standard Tomatis theory or therapy. Further the fact there was no statistically significant difference between the R & F, R and F groups points away from the supposed importance of the Electronic Ear's frequency modulation. Note also the small sample size.

<u>*Gilmor (1999):*</u>

Group: children with learning and communication disorders.

Method: meta-analysis.

This meta-analysis, published in the *International Journal of Listening*, included data from five studies (some of which were unpublished, e.g. doctoral dissertations) investigating the efficacy of Tomatis Method procedures. These were (with some information from the unpublished studies filled in from the review of Gerritsen, 2009):

Study & Group	Methods	Key Findings
Gilmor (1984) An internal study conducted at the Tomatis Centre in Toronto. Group: 102 children (6 to 14	Compared pre-treatment and post-treatment scores for tests of aptitude, achievement, and adjustment. *<u>Limitations:</u> no control group; not independent.*	Apparently supported improvements in learning and communication skills and general adjustment, although the original study is not readily accessible and is not well reported in the meta-analysis.

years).		
Rourke and Russell (1982) Group: 25 learning disabled children (9 to 14 years).	Participants allocated to either a Tomatis treatment (16) or a control group (9) and assessed their performance on various measures of general adjustment, problem-solving, reading and hand-eye coordination quarterly for one year.	Results directionally favoured the Tomatis treatment group. Only differences in WISC Full Scale and Performance IQ scores, the Personality Inventory for Children's adjustment score, the Wide Range Achievement Test (WRAT) standard score, and the Grooved Pegboard Test (GPT) score for the dominant hand were statistically significant.
Wilson, Iacoviello, Metlay, Risucci, Rosati, and Palmaccio (1982) Group: 26 language-impaired preschool children.	Participants allocated to either a Tomatis treatment (18) or a control group (8). The Tomatis treatment group received Tomatis therapy *and* the standard Wilson remedial programme, while the control group received only the standard Wilson remedial programme. After 9 months the researchers compared their auditory processing skills (using tests of sound mimicry and auditory closure) as well as parent and teacher ratings of their general communication ability.	Results (parent/teacher ratings, sound mimicry and auditory closure) directionally favoured the Tomatis treatment group. Only the difference in sound mimicry was statistically significant, although differences between the groups' parent/teacher ratings approached significance.
Mould (1985); Gilmor and Mould (1994) Group: 47 severely dyslexic boys (10 to 15 years).	Researchers conducted two related studies at Brickwall House, a publicly funded boarding school in East Sussex in England. Study 1: 23 severely dyslexic boys allocated to ether a Tomatis treatment group (12) or a control group (11). The treatment group missed 100 hours of normal class over six months to undertake Tomatis therapy while the control group remained in class as usual. Every six months for two years thereafter the boys were assessed using WRAT reading and spelling scores. Study 2: same design as Study 1, except that there were 12 boys in each of the Tomatis treatment and control groups, and the boys were additionally assessed on the Neale Analysis of Reading Ability's accuracy and comprehension scores, the British Picture Vocabulary Scale (BPVS) measure of receptive vocabulary, as well as a measure of verbal fluency.	Study 1: after two years, the Tomatis group showed statistically significantly improvements over the control group on their WRAT reading and spelling scores. Study 2: the Tomatis group improved more than the control group on all measures (WRAT reading and spelling, Neale accuracy and comprehension, BPVS, and verbal fluency) but improvements were only statistically significant for the BPVS and verbal fluency measure.

Kershner (1986); Kershner, Cummings, Clarke, Hadfield, and Kershner (1990) Group: 32 learning disabled children (8 to 14 years).	Students from a privately funded school for students with learning disabilities (whose usual curriculum was based on the Orton-Gillingham approach) were allocated to either a Tomatis treatment (16) or a control group (16). The treatment group were withdrawn from class for six hours per week for Tomatis therapy, up to 100 hours in total. Unlike other studies in this analysis, the control group was an active control. Students in this group were withdrawn for 80 minutes per week, and participated in audio-vocal feedback exercises somewhat similar to those found in Tomatis therapy (although sounds were amplified, they were not filtered, and no bone conductor was used). The control group — but not the treatment group — also received auditory memory training, relaxation training, and individualised reading training. The researchers collected academic and linguistic data (WISC-R, WRAT, Test of Written Language [TOWL], Verbal Fluency, Auditory Closure and Phoneme Blending, Coopersmith Self-Esteem Inventory [SEI]) for both groups over 20 months.	Both the treatment and control groups improved significantly from baseline to post-intervention testing on most measures. However, even though most results directionally favoured the Tomatis treatment group, there was no statistically significant advantage for the treatment group over the control group. The exception to this pattern was the Seashore Rhythm test, which is a test of auditory discrimination where students must distinguish between two rhythmic patterns presented sequentially. The control group performed significantly better than the treatment group on this measure at two-year follow up.

Gilmor argues that (due to there being few statistically significant findings, relatively small sample sizes, and methodological issues, particularly a lack of random assignment) on their own none of these studies provide good evidence for the effectiveness of the Tomatis' method in children learning and communication disorders. He therefore undertook a meta-analysis, assigning each outcome variable from the studies described above to one of five skill domains: auditory, cognitive, linguistic, personal and social adjustment, and psychomotor. Tomatis therapy was shown to significantly improve cognitive (d =.30), linguistic (d = .41), personal and social adjustment (d =.31) and psychomotor (d =.32) skills. Auditory processing skills were not significantly improved, however (d =.04). This due to the conflicting results from the Rourke and Russell and Wilson et al. (d = .47 and .23 respectively) and the Kershner et al. study (d = -.55).

Limitations: meta-analysis does not ameliorate the effects of poor methodology. Only one study in this meta-analysis used fully random assignment of participants to groups. Sample sizes were small, and one study did not have a control group at all.

Neysmith-Roy (2001):

Group: six severely autistic boys (4 years to 11 years).

Method: case studies of behavioural changes.

This article is published in the *South African Journal of Psychology* and details the progress of six boys diagnosed with autism using APA and WHO criteria who underwent Tomatis treatment. Each received Tomatis therapy according to an individualised programme, until either treatment was complete or parents and/or clinical staff decided to terminate it.

At completion of each *Intensive* block, two ten-minute video recordings were made of the boys' play activity. The first recording involved observation of solitary play in a room containing age-appropriate toys. The second involved play with a parent present in the same environment.

After treatment had ended, these video recordings were randomised and scored by two naïve research assistants using the Childhood Autism Rating Scale (CARS). This measure contains 15 subscales — relating to people, imitation, emotional response, body use, object use, adaptation to change, visual response, listening response, taste, smell and touch response, fear or nervousness, verbal communication, non verbal communication, activity level, consistency of intellectual response, and general impression. For each subscale, a child is rated from one to four — one denoting normal age-appropriate behaviour, two mildly abnormal behaviour, three moderately abnormal behaviour and four severely abnormal behaviour. Ratings halfway between points are acceptable as well. These are added together to produce a total CARS score. A total score of between 37 to 60 indicates severe autism, 30 to 36 mild to moderate autism, and 15 to 30 no autism.

Additionally, after each *Intensive* block, a clinical psychologist familiar with the Tomatis method interviewed each boy's parents to record behavioural changes. This data was (somewhat unfortunately) provided to the research assistants to assist in making their CARS determination (as opposed to them relying solely on the video recordings which, because of the randomisation, would not have been subject to an observer-expectancy effect).

The data were as follows:

Participant (Age Treatment Began)	Treatment Description	Pre-intervention CARS Score	Post-intervention CARS Score	Notes
A (around 5 y)	Completed treatment involving eight *intensives* over one year and nine months.	44 (Severely Autistic)	27 (Not Autistic)	Marked improvement in adaption to change, little improvement in verbal communication.
B (4 y 8 m)	Five *intensives* over one year, after which it was decided that there was insufficient progress to justify continuation of Tomatis therapy.	47 (Severely Autistic)	51 (Severely Autistic)	Use of taste, smell and touch markedly improved, but there were a number of other deteriorations – visual response markedly so.
C (5 y 5 m)	Completed treatment involving five *intensives* over nine months.	47 (Severely Autistic)	35 (Mildly to Moderately Autistic)	Marked improvement in the areas of relating to people, emotional response,

				object use, adaptation to change, visual response, listening response and nonverbal communication.
D (3 y 7 m)	Six *intensives* over nine months, after which family had to move to another province.	44 (Severely Autistic)	35 (Mildly to Moderately Autistic)	Marked improvement in adaptation to change, visual response, listening response, response to taste, smell and touch, fear or nervousness, and nonverbal communication.
E (7 y)	Withdrawn by parents following four *intensives*.	46 (Severely Autistic)	47 (Severely Autistic)	Reported that school teachers saw encouraging changes.
F (11 y)	Five *intensives* over six months, after which it was decided to terminate treatment due to a lack of any significant gains.	53 (Severely Autistic)	47 (Severely Autistic)	Some positive change in emotional response and activity level.

In summary, three out of six boys originally classified as severely autistic demonstrated noticeable overall positive changes at the end of Tomatis treatment. Participant A's post-intervention CARS score suggested he was no longer noticeably autistic, while the scores of participants C and D suggested a reduction of symptomatology post-intervention such that they could be classified as only mildly to moderately autistic. These boys were younger when the intervention took place, and changes were most noticeable in 'pre-linguistic' areas.

Limitations: changes were not observed in the remaining three boys. More broadly, it is not possible to draw any firm conclusions based on case studies like this, especially with such a small sample. It is also somewhat regrettable that the research assistants were provided with behavioural reports from parents and teachers as opposed to relying solely on the video recordings alone, which arguably would have provided a more objective measure.

Ross-Swain (2007):

Group: children with auditory processing disorder.

Method: pre-treatment/post-treatment score comparison.

This study, published in the *International Journal of Listening*, assessed the efficacy of the Tomatis method in 41 children (4.3 to 19.8 years) diagnosed with auditory processing disorder. The children underwent 90 hours of Tomatis treatment divided into four blocks (fifteen days passive listening, ten days of active listening, ten days of mixed active and passive listening, then a further ten days of mixed active and passive listening, all separated by three-week breaks). They were not receiving any other therapies at the time. Ross-Swain compared the children's pre-treatment and post-treatment scores on a number of measures, including the:

- Wide Range Achievement Test (WRAT);
- Lindamood Auditory Conceptualization Test (LACT);
- Token Test for Children (TTC), and
- Test of Auditory Perceptual Skills (TAPS).

Analysis revealed significant improvements post-treatment in all subtests of the TAPS and the TTC. No data relating to the WRAT or LACT seems to be reported.

<u>Limitations:</u> Ross-Swain is founder and owner of the Swain Centre which offers the Tomatis programme; unclear why data from the WRAT and LACT were not reported; no control group and so possible test–retest effects; unclear how sample was selected.

<u>*Vervoort, de Voigt, & Van den Bergh (2008):*</u>

Group: four severely neurologically impaired individuals.

Method: case studies with use of EEG.

This article, published in the *Journal of Neurotherapy*, presents four case studies to illustrate behavioural and neurological changes after Tomatis therapy. These are as follows:

Case 1: Lena

- History: retardation in psychomotor and speech development and autistic tendencies; very troubled pregnancy (including loss of amniotic fluid).
  - It is claimed that "the sound transfer of the mother's voice had been far from ideal, because of the diminished amniotic fluid and the enforced laying and resting of the mother". (pp. 41-42)
- Underwent Tomatis therapy from ages 2 to 7.
- Progress was slow at first. EEG at age 4 revealed normal θ rhythm but reduced α and βrhythm, and a weak N200 component in the AEP. Tomatis listening testing at age 5 revealed relatively good bone conduction compared with relatively poor air conduction.
- Retesting at age 7 revealed considerable improvements. The gap between bone conduction and air conduction had narrowed, speech had developed well and spatial errors had decreased. EEG revealed increased alpha activity, and increases in the amplitude of the N100, N200 and P300 components of the AEP.

Case 2: Johanna

- History: extensively retarded development — noticeably including an expressive aphasia, disturbance of observation, and lack of concentration; early birth (35 weeks) by Caesarean section; identified agenesis of the corpus callosum and some cortical atrophy; left hemisphere epileptic activity as identified by EEG. Possible diagnosis of Landau-Kleffner syndrome.
- Underwent Tomatis therapy for 2 years from age 5.
- Initial Tomatis testing suggested a gap between bone conduction and air conduction (which was weak and irregular) and distorted perception in all senses. This was said

to be the cause of Johana's speech and concentration problems. EEG revealed strong δ activity and asymmetry in middle-latency AEPs, apparently indicative of language development disorder.

- Retesting at age 8 years 6 months showed more balanced bone and air conduction and more symmetrical middle-latency AEP amplitudes. Behaviourally she became more engaged, spoke better, could maintain eye contact and showed improvements in fine motor control.
- Note: Johanna was treated with medication (not specified) throughout this study.

Case 3: Francis

- History: diagnosis of autism, suffered from psychomotor retardation, hyperactivity and aggressive tendencies, did not talk; suffered from a shortage of oxygen at birth.
- Underwent intensive Tomatis therapy for 1.5 years.
- Initial testing showed a large gap between bone and air conduction with "strong and chaotic irregularities" (p. 45). Initial EEG results highlighted an asymmetry in middle-latency AEP amplitudes, showing left hemispheric dominance (like Johanna, although more severe).
- Retesting after the 1.5 years of therapy showed an improvement in the balance between Francis' bone and air conduction, although his bone conduction result was still higher than it apparently should have been. New EEG data suggested a normalisation of the middle-latency AEP asymmetry (in fact showing a stronger response on the right than the left). Behaviourally, Francis showed greater focus, alertness and speech.

Case 4: Ambroise

- History: extensive retarded development generally and was difficult to parent. Was born 1 month too early; suffered epileptic attacks from the age of 1.5 months; had suffered brain damage from a fall at age 2 including cerebral haemorrhaging affecting the frontal and left-temporal lobes.
- Began Tomatis therapy at age 2.
- Initial listening testing could not be undertaken. EEG data primarily showed abnormal δ activity and a lack of N100, N200 and P300 components.
- Retesting after six months showed "more harmony" (p. 46) in δ activity and newly developed (but still weak) N200 and P300 components. Behaviourally, Ambroise demonstrated improvements in the use of his limbs and began to babble. He also showed a reduction in epileptic tendencies (note, however, that he was on a dose of Epitomax [Topiramate]).

Limitations: the case study method does not provide credible evidence for a programme's efficacy (certainly nowhere near that of a clinical trial). In particular, given the length of time patients underwent therapy, maturational effects may account for many of the outcomes (especially those relating to theta and delta EEG activity). Also, some strange and seemingly non-scientific claims are made here, e.g. Lena's supposed improved balance between low and high frequencies is said to enable "a better coordination between body and spiritual processes, thus a more structural functioning" (p. 43) — quite what this claim means is not clear to us. Similarly, it is not clear what Ambroise's δ activity being in "more harmony" (p. 46) signifies.

Evidence against efficacy:

General comments:

Although there are a number of articles showing interesting improvements after Tomatis therapy, none convincingly shows that Tomatis therapy is more effective than placebo. There are some common methodological issues. A number of the articles where effects are seen use a case-study method (Gerritsen, 2010; Neysmith-Roy, 2001; Vervoort et al., 2008), which cannot provide convincing evidence of efficacy. Others fail to include a control group (Gillis & Sidlauskas, 1978; Gilmor, 1984; Ross-Swain, 2007), making it hard to disentangle any effect of Tomatis therapy from changes brought about by maturation and undergoing therapy generally. Where a control group is included it tends to be a no-contact control group, which cannot account for motivational/expectancy effects.

Studies where no effect of Tomatis therapy was found:

There are two reported studies of which we are aware where Tomatis therapy was tested experimentally and no effect was found. However, each has its own shortcomings which may provide alternative explanations as to why no effect was found and so they are of somewhat limited value.

The first is the *Kershner et al. (1990)* study (described above as one of the studies forming part of the Gilmor, 1999 meta-analysis) where no significant difference was found between children with learning disabilities who received Tomatis therapy and those who received a placebo treatment. Arguably, however, no difference between the groups was found primarily because the placebo — supposed to be an ineffective treatment used to control for expectancy effects — was itself quite effective (Gerritsen, 2009; Gilmor, 1999). Given that the placebo involved treatment similar to Tomatis training (amplified but unfiltered audio-vocal feedback) as well as auditory memory training, relaxation training, and individualised reading training which the Tomatis group did not receive this is not an argument that can be easily dismissed.

The second is the study of *Corbett, Shickman, & Ferrer (2008).* This was a double-blind, placebo-controlled crossover study evaluating the efficacy of 90 hours' Tomatis therapy in 11 autistic boys. Each boy was randomly assigned to either Group 0 (placebo then treatment) or Group 1 (treatment then placebo). The placebo condition involved listening to Mozart and Gregorian chant CDs (as would be used in Tomatis treatment), but not filtering these through the electronic ear or doing any audio-vocal feedback exercises. Measures included the Autism Diagnostic Observation Schedule (Generic, ADOS-G), the Stanford-Binet Intelligence Scale (Fourth Edition, SB4), the Peabody Picture Vocabulary Test (Third Edition, PPVT-III) and the Expressive One Word Vocabulary Test (EOWVT), scored at baseline, and after the first and second rounds of treatment. ANOVA revealed no significant differences between the groups on language measures. All of the boys showed improvement over time but this did not appear to be related to their treatment condition. The authors could not identify whether general developmental progress or some other variable was driving this improvement.

However, this study also suffers from its own limitations:

(1) A cross-over design is not appropriate given that Tomatis therapy may have a lasting or carry-over effect (Gerritsen, 2008, 2010) — i.e., it may work by laying a cognitive base which requires time and further environmental enrichment to produce behavioural changes. This may have contaminated the results for Group 1 who received Tomatis treatment first, then the placebo.

(2) In any case, the sample size was small, and so statistical power to detect an effect was low. Gerritsen (2010) goes so far as to argue that given previous data

(Neysmith-Roy, 2001) had shown 40% of those with autism will not respond to Tomatis therapy, Corbett et al. should have separated responders from non-responders and analysed the data separately (although this is not necessarily a methodological suggestion we would endorse!).

(3) Some behavioural assessment data was collected but not reported — only data on language skills was reported (Gerritsen, 2008, 2009, 2010).

Gerritsen (2010) reanalysed Corbett et al.'s data as 11 case studies. Her reanalysis included the unreported data — which was data from the BASC (Behaviour Assessment System for Children, based on parents' ratings) and the VABS (Vineland Adaptive Behaviour Scales). She argues that a meaningful change in at least one measure was observed six of the 11 children. Still, the case study method does not provide the same rigor as an experimental trial. Further well-controlled experimental studies with adequate sample sizes are certainly needed.

Price:

Varies depending on provider and how many Intensives are required. Talk About Curing Autism (2003) reported the price at that time was USD 1,800 for the first (longer) intensive and 1,000 for the intensives thereafter.

Note:

There are a number of programmes which explicitly modify and incorporate components from Tomatis therapy. These include Berard's Auditory Integration Training (http://www.aithelps.com), the Integrated Listening Systems programme (http://integratedlistening.com), Joudry Sound Therapy (http://soundtherapy.com.au), Madaule's Listening Fitness (LiFT) programme (http://www.listeningfitness.com), Samonas Sound Therapy (http://www.samonas.com) and The Listening Program (http://a.advancedbrain.com/tlp/the_listening_program.jsp).

The research discussed above refers only to studies using Tomatis equipment/procedures. For a review of Berard's Auditory Integration Training — which is more popular than Tomatis therapy in the United States — see the American Speech-Language-Hearing Association's (2004) Technical Report, where its inclusion as a mainstream treatment for communication, behavioural, emotional, and learning disorders is rejected. For a review of Auditory Integration Training as it relates specifically to autism spectrum disorders, see the Cochrane review (Sinha, Silove, Hayen, & Williams, 2011). Finally, for a comparison of the contents of some of the Tomatis offshoots, see Thompson & Andrews (1999).

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III OMITTED PROGRAMMES

In preparing this technical report we were referred to a number of other programmes for which we ultimately did not prepare full notes. These are discussed briefly below.

4D l For Dyslexia

http://www.4d.org.nz/

4D provides comprehensive dyslexia resources and information, with the goal of accommodating individuals with dyslexia in their personal, work and educational lives. The resources can be of use to individuals with dyslexia, but can also assist those who interact with dyslexic individuals, e.g. employers, educators, in developing a dyslexia-friendly environment.

Reason(s) for Omission: The focus of this approach is on accommodation, not remediation.

Buzan Mind Mapping

http://www.tonybuzan.com/about/mind-mapping/

Tony Buzan claims mind mapping "is a powerful graphic technique which provides a universal key to unlock the potential of the brain" and that it "harnesses the full range of cortical skills – word, image, number, logic, rhythm, colour and spatial awareness". He continues to provide instructions and training sessions for mind mapping.

Reason(s) for Omission: While no doubt useful, this is not a remediation programme.

Developmental Learning Centre

http://www.developlearning.co.nz/

The Developmental Learning Centre combines two types of therapy and offers this to children in Auckland and Tauranga. It integrates the Integrated Listening Systems Programme (a Tomatis offshoot — see the notes for that programme) and Extra Lesson, a form of developmental movement therapy.

Reason(s) for Omission: This is not a widely-available remediation programme in and of itself. Tomatis and its offshoots are covered in their own section, and there does not appear to be any peer-reviewed evidence available in support of Extra Lesson.

EFT Tapping Technique

http://efttappingtechniques.com/eft-tapping-basics/eft-tapping-emotional-tapping-2/

Emotional Freedom Techniques involves tapping/stimulating acupuncture points in an attempt to improve psychological problems.

Reason(s) for Omission: EFT is essentially a form of alternative medicine and has been strongly criticised for being pseudoscientific, with no benefit beyond a placebo effect (Bakker, 2013). Additionally, there is no evidence to support the theory and mechanisms underlying EFT's alleged effectiveness (Bakker, 2013).

Feuerstein Programme

http://www.nzfeuerstein.org/

The Feuerstein programme is a cognitive intervention targeting learning-disabled, normative and gifted children.

Reason(s) for Omission: It is unclear what the programme is targeting. A Feuerstein instructor would not comment on the underlying mechanisms that allow "interven[ing] and strengthen[ing] the weak cognitive capacities that affect our learning", to "'re-design' our brains". Additionally, and because the programme is marketed as suitable for all children, it is difficult to objectively assess claims of effectiveness across very different population samples.

Neurolink (NIS)

https://www.neurolinkglobal.com/

Neurolink/NIS is a programme developed in New Zealand to address a wide range of complaints, including aging (arthritis/joint degeneration/osteoporosis), allergies, asthma, back & neck pain, chronic fatigue, circulation/blood pressure issues, depression, anxiety and stress, digestion issues, learning/behavioural issues (including ADHD/dyslexia/hyperactivity/ Asperger's/dyspraxia), men's health issues, migraine & headaches, neurological injury (trauma), skin problems (eczema/ dermatitis/ psoriasis), sleep disorders (insomnia/apnoea/ tiredness), issues with viruses and immunity (colds & flu), and women's health issues (fertility/PMT/menopause/pregnancy).

These complaints are addressed through a technique involving muscle-testing and then the practitioner holding different points (informed by the meridian system) on the patient's body to activate different malfunctioning 'circuits'.

Reason(s) for Omission: Neurolink is more accurately characterised as an alternative medicine programme than a cognitive remediation programme. There is no scientific evidence to support its efficacy.

Sensory Integration Therapy

http://www.childsplayot.co.nz/

http://www.sensory-processing-disorder.com/sensory-integration-activities.html

Sensory integration (SI) is described as the central nervous system's ability to organise sensory feedback from the body and environment, so that the individual can make adaptive responses (Shaw, 2002). SI therapy assumes that learning and developmental difficulties occur partly due to differences in the neurological processing of vestibular, tactile and proprioceptive sensory information (Hyatt, Stephenson, & Carter, 2009). The therapy aims to link adaptive responses to sensory input by trying to "revisit and restructure the development of sensory integration in cases where the normal development progression has been disrupted" (Shaw, 2002).

The therapy uses activities and resources such as deep brushing, scooter boards and swings/hammocks for vestibular input, weighted vests, manual compression of joints, textures and generally an increase and decrease of "sensory diet" (Shaw, 2002; Vargas & Camilli, 1999).

Reason(s) for Omission: Though initially the programme was intended for those with learning disabilities (Shaw, 2002), it is now more commonly used by occupational therapists to treat children with Autism Spectrum Disorder. Additionally, the therapy is individualised based on the child's needs, whereas this project's focus is on more group-based and computerised programmes. There has also been some controversy surrounding SI therapy. Review and meta-analysis papers have generally deemed it ineffective (Hoehn & Baumeister, 1994; Shaw, 2002), with claims that the practice is on the verge of being pseudoscientific.

SPELD

SPELD is a New Zealand voluntary organisation which provides — among other services — intensive one-on-one remedial tuition for children with dyslexia.

SPELD remediation is not based on standard scripted tuition. Instead, SPELD teachers give individualised instruction in "phonological awareness; phoneme/grapheme knowledge; visual and auditory processing; processing speed; and sequencing" as is deemed necessary from pre-remediation assessment results (Waldie, Austin, Hattie, & Fairbrass, 2014). In the Waldie et al. study this involved assessment using the Woodcock-Johnson III tests of cognitive abilities and of achievement.

In contrast to other programmes (e.g., Arrowsmith) which see cognitive remediation as a form of normalisation or cure, SPELD (n.d.) claims on its website that "[s]pecialist help may not be able to cure dyslexia, but research based help and teaching can lessen its effects markedly."

The Waldie et al. (2014) pilot study provides evidence for SPELD's efficacy (although is limited by lack of a control group).

Reason(s) for Omission: SPELD is a promising intervention programme, but its delivery is one-on-one (as opposed to being whole class or computer based) and, further, its content differs markedly from tutor-to-tutor and child-to-child. Consequently, the preparation of a full report was not deemed useful.

Therapro

http://www.therapro.com/

Therapro is a website that sells unique therapeutic and educational resources for individuals of all ages and abilities. Its products are primarily for speech and occupational therapy.

Reason(s) for Omission: This is a website selling products aimed at improving learning and learning difficulties, rather than a remediation programme.

Wobble Board

http://www.wobbleboard.co.nz/special.asp

A wobble board is a device used to primarily for "building strength in the muscles, joints, tendons and ligaments of the lower body'. The website claims that the wobble board can also improve neurological function and assist in treating/curing dyslexia and dyspraxia.

Reason(s) for Omission: This is not a remediation programme, but a product that is to be used in conjunction with an intervention. While there is evidence to suggest that the wobble board can improve balance (e.g. Onigbinde, Awotidebe, & Awosika, 2009), the claim that it can be used to treat dyslexia appears to be unsubstantiated.

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IV CONCLUSION

The science behind cognitive remediation is still in its early age, and is therefore a work in progress — each new piece of evidence allows us to refine current models of behavioural intervention. In our view, a few tips can go a long way when assessing intervention programmes:

- *Be sceptical*. Neuroplasticity-based claims are everywhere. Although convincing science has shown that the brain can adapt and reorganise itself in some instances, marketing claims often go far beyond the actual evidence they are supposedly based upon. Being sceptical does not mean refuting scientific advances — it means demanding sound evidence before embracing a particular program or intervention.

- *Keep an eye out for alternative sources of information, especially from non-profit organisations*. Commercial companies often have interesting anecdotes or claims about their product, but one should be wary if this is the only source of information supporting the benefits of a programme. Remember that companies have financial incentives tied with the effectiveness of their product — consult independent, peer-reviewed evidence.

- *Seek expert opinions*. Talks, publications and seminars from scientists around the world can provide you with relevant information regarding the programmes you are interested in. Do not hesitate to reach out to them! In particular, peer-reviewed publications and news at our website (www.movincog.org) can help you navigate through the sometimes overwhelming bulk of information in this field. We are a research group based at the Centre for Brain Research, at the University of Auckland, and do not financially benefit from the claims we make. We are interested in advancing scientific knowledge about cognitive interventions to help provide the best information available so that parents, educators and policy-makers can reach their own conclusions.