Theoretical background to Move4words and supporting academic research references.

By Elizabeth McClelland

Contents:

Published evidence for effects on learning and literacy of other movement programmes

- Ulrich and Swalm (2007) reported significant improvements ($p < 0.05$) in reading comprehension for the bi-manual coordination programme group (called sports stacking) which were significantly better than for the control group.

- Jordan-Black (2005); The Primary Movement programme, extremely slow exercises designed to mimic baby reflex movements. The experimental groups (Year 3 and Year 5) made significantly more progress ($p < 0.001$) in reading and mathematics than the control groups.

- McPhillips et al. (2000); a randomized double blind movement placebo controlled trial of the effects of the Primary Movement Programme, developed by McPhillips, on reading ability of dyslexic children aged 8-11 years. Both reading and naming speed improved significantly more for the experimental group ($p < 0.001$) than for either of two control groups (baseline control and movement placebo control).

- Byl et al. (1989). This study investigated the effects of a vestibular exercise programme with boys aged 7 to 12 years who had problems with attention and learning to read. The gain in reading grade was + 3.5 months for a comparison aerobic exercise group and + 8.5 months for the vestibular exercise group and this difference was significant ($p < 0.05$). Byl et al. suggest that the most important factor that was improved by their vestibular exercise programme is the subject's attention.

These studies show positive impact of sensorimotor programmes on learning and literacy. This evidence supports the basic premise of Move4words, which is that learning can be enhanced by developing specific physical motor skills.

Underlying physiological and cognitive effects

Mechanisms which might contribute to the effects of Move4words - a personal view by Dr Elizabeth McClelland

The fundamental answer is that the underlying neurological, physiological and cognitive effects of Move4words has not yet been investigated, so we can't actually know for sure.

The two main aims of the Move4words programme are of raising the brain's ability to pay attention, and helping to build executive function. However, there are a number of other themes in the programme, and an outline of evidence for the contribution of each theme to development of reading difficulties and their solution is described below.

It is very hard to learn if you can't concentrate, so concentration is a vital skill. However, we tend to assume that children could concentrate if only they tried, so that will-power is all that is needed. Concentration and attention skills are built with the Move4words programme with simple physical, visual and auditory activities.

It is likely that key elements of executive function (the brain function which enables us to think, plan and act) are built by daily repetition and chunking of skill acquisition, and these elements are embedded into the activities of the 12-week Move4words Literacy Booster.

MOVEMENT AND LEARNING ARE LINKED – EMBODIED COGNITION

We have considerable evidence, some with movement placebo control, that Move4words does have significant impact on literacy and learning. But WHY might Move4words work? Received wisdom would say that the only thing which will improve reading skills in children is more or better literacy teaching, so how could the addition of movement to the learning curriculum provide any benefit for school children?

Recent developments in cognitive science suggest that there is much more to thinking and learning than previously supposed. The radical concept of "embodied cognition" says that our brains cannot solve problems unaided, and that our bodies play an essential role in any form of thinking or problem-solving. For example, Anne Olmstead of the University of Connecticut, and her colleagues, have shown that tiny muscle movements in the hands are a fundamental part of language comprehension.

For an in-depth exploration of embodied cognition, see Andrew Wilson's blog at http://psychsciencenotes.blogspot.co.uk/2011/11/embodied-cognition-is-not-what-you.html and the links therein. Dr Wilson is director of the Perception-Action Lab at the University of Leeds and a leading researcher in the field.

The field of robotics has had a surprising and important input to this field, as developers and researchers discovered that robots could only be designed to effectively solve problems when they were given the ability to interact with their environment (brain/body), rather than using abstract thought processes generated by computer software (brain).

This new approach opens up the exciting possibility that improving brain/body communication and control could indeed improve cognitive performance, by improving the effectiveness of the whole interactive brain/body problem-solving system.

There is growing support for this idea in various areas of research into the origins of reading difficulties.

Some relevant embodied cognition references:

Olmstead, A. J.; Viswanathan, N.; Aicher, K. A.; & Fowler, C. A. (2009). "Sentence comprehension affects the dynamics of bimanual coordination: Implications for embodied cognition". *The Quarterly Journal of Experimental Psychology* **62** (12): 2409–2417.

Boulenger, V., Roy, A.C., Paulignan, Y., Deprez, V., Jeannerod, M., & Nazir**,** T.A., (2006) Cross-talk between Language Processes and Overt Motor Behavior in the First 200 msec of Processing. *Journal of Cognitive Neuroscience*, **18** (10), 1607-1615

PAYING ATTENTION:

- We only perceive the world in disconnected fragments and our brains fill in the gaps to make an apparently seamless reality. Attention is largely an automatic process and it is hard to control what we pay attention to. What our brains ignore is largely based upon our previous experience, and what we have learned to pay attention to is largely what we have learned is important for our basic survival needs. Children who find it harder to learn may pay attention to and ignore rather different sensory stimuli compared to more successful children.

- With its focus on sensory awareness training (through the visual, auditory and sensory pathways) Move4words may simply help the brain to notice more of the world around so a more accurate picture can be created, allowing learning to happen in a natural fashion.

- Humans have evolved to pay attention to everything around them at once, so they can be alert to any dangers. Children have to learn how to switch off certain areas of attention, so that they can concentrate on their school work. It is easier to learn to pay attention by doing physical tasks than to try to concentrate on thinking skills.

Relevant attention and literacy references:

Shaywitz and Shaywitz, 2008. Paying attention to reading: The neurobiology of reading and dyslexia. *Development and Psychopathology* v20: p1329-1349

Bosse and Valdois, 2009. Influence of the visual attention span on child reading performance: a cross-sectional study. *Journal of Research in Reading*, 32 (2), 230-253.

AUTOMATICITY

Our brains need to be able to process information automatically to be effective at anything.Once you progress from learning to read to reading to learn, reading has become automatic. When children have not yet become able to read automatically, then learning is considerably more difficult.

- Correlations between poor concentration and poor motor skills have been identified

- Authors have suggested that poor automaticity of motor performance are correlated with reading difficulties

Relevant Automaticity References:

Raberger and Wimmer, 2003. On the automaticity/cerebellar deficit hypothesis of dyslexia: balancing and continuous rapid naming in dyslexic and ADHD children. Neuropsychologia, 41 (11), 1493 - 1497.
Ramus, Pidgeon and Frith (2003). The relationship between motor control and phonology in dyslexic children,. *J Child Psychol Psyc,* 44 (5) 712 - 722.
Savage et al, (2005). Evaluating current deficit theories of poor reading: role of phonological processing, naming speed, balance automaticity, rapid verbal perception and working memory. *Perceptual and Motor Skills*, 101, 345 - 361

MOVEMENT:

When we think and solve problems, we use many of the same parts of the brain we use to plan movements.

- "Exercise performed on a regular basis for several weeks alters brain functions that underlie cognition and behavior." (Tomporowski et al., 2008) Effect sizes for the effect of exercise on learning are about 0.25 (Etnier et al., 2006), considerably smaller than effect sizes of 0.5 to 0.8 for Move4words interventions.

- 15 minutes of aerobic exercise in the classroom significantly improved attention for children aged 8 – 11. (Hill et al., 2010)

- There is evidence that poor readers do commonly have motor coordination difficulties. Wolfe (2007) demonstrated that motor fluency and control correlate positively with phonological awareness of reading-disabled children. Dewey et al. (2002), Jongmans et al. (2003), and Iversen et al. (2005) all demonstrated that significantly more poor readers, both dyslexic and non-dyslexic, had poor balance and motor coordination than control groups of good readers.

Relevant Movement References:
Dewey, D., Kaplan, B.J., Crawford S.G. &Wilson, B.N. (2002). Developmental coordination disorder: Associated problems in attention, learning, and psychosocial adjustment. *Human Movement Science,* 21, 905–918.
Etnier, J.L., Nowell, P.M., Landers, D.M. & Sibley, B.A. (2006). A meta-regression to examine the relationship between aerobic fitness and cognitive performance. *Brain Research Reviews,* 52, 119-130.
Jongmans, M.J., Smits-Engelsman, B.C.M. & Schoemaker, M.M. (2003). Consequences of comorbidity of developmental coordination disorders and learning disabilities for severity and pattern of perceptual-motor dysfunction. *Journal of Learning Disabilities,* 36, 528-537.
Hill et al., (2010) "Exercising attention within the classroom", *Developmental Medicine and Child Neurology.*
Iversen, S. K., Berg, K., Ellertsen, B. & Tonnessen, F.-E. (2005). Motor coordination difficulties in a municipality group and in a clinical sample of poor readers. *Dyslexia,* 11, 217–231.
Pope and Whiteley, 2003. Developmental dyslexia, cerebellar/vestibular brain function and possible links to exercise-based interventions: a review". *European J Special Needs Education. 18 (1), 109 - 123.*
Tomporowski et al., (2008) "Exercise and Children's Intelligence, Cognition, and Academic Achievement", *Educational Psychology Reviews (an academic research journal)*
Wolfe, C.B. (2007). Motor control and reading fluency: contributions beyond phonological awareness and rapid automatized naming in children with reading disabilities. PhD diss. Georgia State Univ.

RHYTHM

Links between rhythm and literacy - practical observations

- Rhythmic ability at age 6 is strongly linked with children's ability to rapidly put a name to a picture, their word identification and phonological awareness, and this is true at least up to age 11. (David et al, 2007)

- The effect of poor rhythmic ability is to produce an experience for a child with dyslexia which is similar to "listening to a non-native speaker speaking your language with the stresses in the wrong place", according to Professor Goswami, Cambridge University. On the basis of this, she says that it is important for teachers to use not only phonics with young children, but "broad-based approaches to language, such as clapping along to syllable patterns in nursery rhymes and making large movements to language".

- Being able to hear the **rhythm** in speech is necessary before progressing to phonemic awareness and reading. Holliman et al, 2008.

Relevant Rhythm References:
David et al, 2007. Rhythm and reading development in school-age children: a longitudinal study. *Journal of Research in Reading*, 30 (2), 169–183
Hinds, D, 2005. Linking Rhythm to Reading, Times Educational Supplement, 2 December 2005. http://www.tes.co.uk/article.aspx?storycode=2199685

Holliman et al, 2008. Sensitivity to speech rhythm explains individual differences in reading ability independently of phonological awareness. *British Journal of Developmental Psychology*, 26 (3) 357-367

MUSIC

Regular listening to rhythmic melodic music appears to improve reading and academic performance.

- Regular use of background melodic music in the Primary classroom improved reading scores (Dawson, 2003; Hallam et al, 2002).

- Baroque music helps the brain to organise incoming information and improves attention (Sridharan et al, 2007).

Relevant music and learning references:
Dawson, 2003. Listening to music and increasing reading achievement scores in vocabulary and comprehension, and total reading ability. (Doctoral dissertation, Western Michigan University).
Hallam et al, 2002. The Effects of Background Music on Primary School Pupils' Task Performance. Educational Studies, 28, 111 – 122.
Sridharan et al, 2007. Neural dynamics of event segmentation in music: converging evidence for dissociable ventral and dorsal networks. *Neuron, 55,* 521 – 532.
http://www.sciencedaily.com/releases/2007/08/070801122226.htm

LEFT/RIGHT-SIDED BODY COORDINATION:

Inefficient transfer of information between the two cerebral hemispheres is linked with problems with reading (at least for dyslexic subjects).

- "Various types of dyslexia have been associated with tactile-motor coordination deficits and inefficient transfer of information between the two cerebral hemispheres." (Moore et al., 1995)

- Poor reading is correlated with impaired inter-hemispheric co-ordination of information while reading for dyslexic children (Shillcock and McDonald, 2005).

- Children with learning disabilities find it more difficult to reach across their body to achieve a manual dexterity task (known as midline crossing inhibition, Surburg and Eason, 1999).

- The region in the brain in which sensorimotor signals are transferred between hemispheres is generally smaller in dyslexic children compared to controls. (Von Plessen et al., 2002; the posterior mid-body section of the corpus callosum leading to the splenium)

- Perhaps the gradual build-up of movement skills leading to left-right coordination of physical activity in Move4words helps inter-hemispheric coordination of orthographic information, thereby improving literacy skills.

Relevant Inter-hemisphere information transfer references:
Davidson, R.J., Leslie, S.C. & C. Sarong. (1990). Reaction time measures of interhemispheric transfer time in reading disabled and normal Children. *Neuropsychologia,* 28, no. 5, 471-485.
Moore, L.H., W.S. Brown, T.E. Markee, D.C. Theberge, and J.C. Zvi. 1995. Bimanual coordination in dyslexic adults. *Neuropsychologia* l 33, no. 6: 781-93.
Shillcock, R.C. and S.A. McDonald. 2005. Hemispheric division of labour in Reading. *Journal of Research in Reading* 28, no. 3: 244–57
Surburg, P.R. and Eason, B. 1999. Midline-crossing inhibition: an indicator of developmental delay. *Laterality*, 4 (4), 333-43.
von Plessen, K., Lundervold, A., Duta, N., Heiervang, E., Klauschen, F., Smievoll, A.I., Ersland, L. & Hugdahl, K. (2002). Less developed corpus callosum in dyslexic subjects—a structural MRI study. *Neuropsychologia,* 40, 1035–1044

MENTAL CONTROL AND SELF-REGULATION:

Executive function is the "conductor of the orchestra" in the brain. It helps connect previous experience with present thought and action. It is used to perform activities such as planning, organizing, problem solving, paying attention to and remembering details, and managing time and space. Executive function is thought to be controlled by the pre-frontal cortex which conducts activity across the rest of the brain.

Without well-developed executive function, we cannot effectively think, act or solve problems.

- To develop successfully, children need repeated practice and to progressively increase the challenge to executive functions. These challenges need to be intellectual, **physical** AND social. Development which does not include all three areas is thought to be imbalanced. The main focus of the Move4words programme is an increasing in complexity of each of the strands of the programme, gradually increasing the daily challenge to the child, throughout the programme.

- Three main elements of executive functioning, cognitive flexibility, goal setting and information processing appear to develop mainly during the age range 7 to 9 years (Anderson, 2002) and are usually relatively mature by 12 years of age.

- Deficits in executive functioning are thought to contribute to many learning difficulties, including autism, ADHD, Dyslexia, Conduct disorders, depression, and foetal alcohol syndrome.

Relevant Executive Function References:
Anderson, P. (2002). "Assessment and Development of Executive Function (EF) during Childhood." Child *Neuropsychology, 8 (2),* 71-82.
Diamond and Lee (2011). "Interventions shown to aid executive function development in children 4 to 12 years old". *Science, 333 (6045),* 959-64.

Gooch, D et al. (2011). "Time perception, phonological skills and executive function in children with dyslexia and/or ADHD symptoms." J. Child Psychol. Psychiatry, 52 (2), 195-203.

MULTI-SENSORY EFFECTS:

Most reading problems seem to have a fundamental sensori-motor cause (Stein, 2001).

- Children diagnosed with dyslexia often have visual, auditory and motor problems (Stein, 2001)
- The cerebellum is a part of the brain which has a clear role in coordinating movement. More recent neuroscience has highlighted the role that the cerebellum plays in reading, indicating that it plays an important role in word recognition (Fulbright et al, 1999).
- Poor reading is linked with general difficulty in performing skills automatically. Scientists have demonstrated that these problems are commonly linked to cerebellar impairment (Nicholson et al, 2001)

Multisensory problems references:

Fulbright et al, 1999. The Cerebellum's role in reading: a functional MR imaging study. *Am. J. Neuroradiology*, 20, 1925-1930.
Nicholson et al, 2001. Developmental dyslexia: the cerebellar deficit hypthesis. *Trends in Neurosciences*, 24 (9), 508-511.
Stein, 2001. The Magnocellular theory of developmental dyslexia. *Dyslexia,* 7, 12-36.

VISION

Reading is predominantly a visual experience as well as an auditory and phonic experience.

- Visual attention is at least as important as phoneme awareness in the development of reading, particularly as reading matures. (Bosse and Valdois, 2009)
- Eye tracking exercises can significantly improve reading age, as used by the Dyslexia Research Trust (Clisby et al., 2000).

Relevant Vision References:

Bosse and Valdois, 2009. Influence of the visual attention span on child reading performance: a cross-sectional study. *Journal of Research in Reading*, 32 (2), 230-253.
Clisby C., Fowler, M.S., Hebb, G.S., Walters, J., Southcott, P. & Stein, J.F..(2000). Outcome of treatment of visual problems in children with reading difficulties. *PATOSS Bulletin* Nov., 9-14.

RELAXATION:

Teachers generally agree that children and students learn better when they are relaxed and feel safe. Furthermore the new technique of Mindfulness is thought to improve cognitive processing and self-control.

- Secondary school students who were taught Mindfulness self-relaxation exercises performed significantly better in dictation tests, making fewer mistakes and scoring higher than matched students who did not do the relaxation exercises (Krampen, 2010).

- College Computer Science students achieved significantly higher scores in tests when trained in upper limb relaxation exercises than matched student controls (Yusoff and du Boulay, 2009).

- Poor reading and poor school grades is correlated with higher levels of depression in children starting Secondary School (Vincenzi, 1987)

Relevant relaxation and learning references:

Krampen, 2010. Improvement of orthography test performance by relaxation exercises: results of a controlled field experiment in basic secondary education. *Educational Psychology*, Volume 30 (5), 533 – 546.
Vincenzi, H, 1987. Depression and reading ability in sixth-grade children. *Journal of School Psychology*, 25, 155 - 160.
Yusoff, M.Z. and du Boulay, B., 2009. The integration of domain-independent strategies into an affective tutoring system: can students' learning gain be improved? *Electronic Journal of Computer Science and Information Technology*, 1 (1), 23-30.