The Body Learns Too: How the Brain–Body Relationship Helps to Lay Down Highways of the Mind

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Summary

In July this year, I was asked to contribute to the Embodied Cognition International Conference focusing on the brain–body relationship. The following article is a transcript based on this presentation, which examined the human mind in the context of the relationship between the brain, body and environment, with neuromotor maturity providing a reflection of congruence in this functional relationship. The role of neuromotor immaturity in learning, achievement and emotional regulation is discussed based on a series of studies and projects carried out over the last 16 years, which have examined the neuromotor status of children in mainstream schools and the impact of physical remediation programmes.

Keywords: embodied cognition; neuromotor maturity; learning readiness; primitive reflexes; postural control; visual-perception; relationships

Introduction

For generations, the most brilliant minds in the fields of philosophy, science and the arts have searched and debated the question, what is the human mind? Although perception of experience and the generation of thought take place in the brain, the brain does not function in isolation. Its condition is interdependent with the body and its continuously adapting relationship with the environment. In this relationship, physical development acquired through the dual processes of maturation *and* experience plays a crucial role in laying the foundations for life, learning and living, consistent with the concept of Embodied Cognition – the idea that the mind is not only connected to the body but that the body influences the mind – and also the first principle of Humanistic Psychology, that human beings supersede the sum of their parts, and they cannot be reduced to components.

One method of examining the brain–body–environment relationship is through the presence or absence of acknowledged markers of child development, which provide reflections of maturity in the functioning of the central nervous system (CNS) under different environmental conditions. Maturity in functioning of the CNS has a profound influence on perception, learning and behaviour.

One of the features of technologically advanced societies is that they tend to be driven by economics and the pursuit of outcomes rather than processes, a trait which is in direct contrast to how children develop and learn. Arthur Paynter, a retired paediatrician, observed that, 'in order to explore the unknown, a child must first have one foot firmly in the known'.[1] In other words, a child first needs to have firm roots in physical space to grow and to absorb new knowledge. In this respect, physical competence and confidence in space provide the foundation not only for physical balance, postural control and co-ordination, but also for perception, which is vital to support cognitive processes and emotional attribution. Problems in the brain–body–environment relationship will be reflected not only in specific physical skills but also in the mental operations that those skills support.

In 1975, psychologist Peter Blythe, who had worked in psychotherapy and as a senior lecturer in applied psychology and education, founded the Institute for Neuro-Physiological Psychology (INPP) as a private research, clinical and training organisation. During his years in practice and further education he had become increasingly aware of the role of physical factors in the development of secondary neuroses and educational difficulties, and with these in mind, he established INPP.

The focus of INPP was to be:

1 To research into whether immaturity in the functioning of the central nervous system might underlie symptoms of anxiety, agoraphobia and panic disorder in adults, and the presentation of

specific learning difficulties and under-achievement in children;

2 To develop reliable methods with which to assess maturity of function in the central nervous system;

3 To develop effective physical programmes to improve functioning of the central nervous system; and

4 To evaluate the efficacy of specific developmental movement programmes in improving measures of immaturity and presenting symptoms.

To this end, Blythe and his colleagues developed a series of standard assessment tools and a physical remediation programme for use in clinical practice. This has since been adapted to provide a screening test and intervention programme for teachers to use in schools[2] and a screening test for clinicians.[3]

Results obtained from application of the school-based screening test since 2004 have indicated that there is a significant percentage of children in mainstream schools in the United Kingdom and in a number of other countries who have immature motor skills, and that there is a relationship between neuromotor immaturity (NMI) and lower academic performance.[4]

Introduction of the INPP developmental movement programme into schools has indicated that signs of NMI improve with the use of a specific developmental movement programme, and that improving motor skills can impact other skills in addition to physical co-ordination. In other words, daily physical exercise has an influence on more than simply co-ordination, fitness, strength and stamina. Why?

One answer can be found in the relationship between experience and perception. Perception, on which cognitive processing depends, requires that the brain receive coherent information from the senses, but perception involves more than just the flow of information from individual senses. Perception – how the brain interprets information – involves integration of information from each of the senses involved. Sensory integration is a developmental process during which the experience of movement acts as a primary *medium* of training, which strengthens and improves the efficiency of neural pathways that are in regular use. In this respect, motor action and movement experience help to build neural motorways for the mind.

Innately involved in this process is the functioning and entrainment of the interoreceptor systems – sometimes referred to as the 'hidden senses' – of balance (vestibular) and proprioception. These two systems are important because they provide the brain with an internal sense of physical position in space, which acts as the basis not only for the obvious functions of balance and postural control, but also for centres involved in the control of eye movements, necessary for stable visual perception.

Physical stability in space also provides a physical reference point for supporting the cognitive sense of space and mental operations in space – knowing where we are – and being able to navigate in space. Physical stability provides a secure platform for balance and postural stability in space, which also supports perception and emotional reaction to sensory stimuli, thereby also supporting emotional security.

The vestibular system is unique in that it has no special sensation of its own. Vestibular functioning only reaches conscious awareness if it is over-stimulated, disturbed or dysfunctional: then it 'speaks' by heightening arousal, increasing sensitivity in other sensory systems and affecting vegetative functions. Motion sickness is one example of this, when a particular plane and/or speed of motion stimulates one part of the vestibular system, shifting it out of kilter with other parts and/or other sensory systems involved in the perception of motion such as vision or proprioception.

Visual symptoms of vestibular dysfunction may include blurring, the illusion that stationary objects are moving (objective vertigo) or that the self is moving (subjective vertigo). Additional symptoms can be dizziness and disorientation, any of which make it difficult for the brain to maintain a coherent picture of the outside world. All of the physiological symptoms associated with anxiety such as acceleration or deceleration of heart rate, breathing, 'jelly' legs and nausea, can be elicited by inappropriate stimulation of the vestibular system, resulting in a physical trigger to somatic symptoms, emotional reactions and the cognitive interpretation of anxiety.

Proprioception – the feedback received from relative tension in the muscle spindles, tendons and joints – provides the brain with its sense of position and position of body parts, is necessary not only to know where parts of the body are at any time, without relying on vision to support it, but because accurate

feedback is necessary for areas in the brain involved in motor planning to work out how to carry out movement sequences. Impaired proprioceptive functioning can result in what appears to be a primary motor planning problem, but is a secondary consequence of impaired proprioceptive feedback. Proprioceptive functioning is also important for knowing where parts of the body are in space and for developing a sense of body map.

One way to improve the functioning of both the vestibular and proprioceptive systems is through movement and motor training carried out with the eyes closed. Both the stimulation provided by motion and the proprioceptive feedback derived from movement experience can help to improve the functioning of these interoreceptor systems, providing a more stable basis for control of balance, posture, co-ordination in the absence of visual cues, while also providing a more secure platform for centres involved in the control of eye movements. In other words, internal stability supports systems designed to process the external world.

Postural control is the product of synergetic interaction between systems: vestibular, visual and proprioceptive systems co-ordinated and supported by the efficient functioning of anti-gravity reflexes, which develop in the first year(s) of life; postural control (equilibrium, posture and tonus), which provides the background framework of reference for acuity and accuracy of visual pursuit and the development of independent use of the two sides of the body – a precursor to functional lateral preference, traditionally considered to be indicative of 'readiness' for reading. Postural control depends on maturity in the functioning of the supporting neuromotor system.

How can we recognise immaturity in the functioning of these systems?

During the process of normal development, reflexes emerge, are inhibited by higher centres in the developing brain and/or are integrated into the service of more complex patterns of movement, including postural reactions. The presence or absence of primitive and postural reflexes at key stages of development can provide signposts of maturity in the functioning of the central nervous system.

Primitive reflexes are mediated at the level of the brain stem, develop during life in the womb, are active in the healthy neonate born at full term, and are inhibited by six months of post-natal life.

Postural reflexes, also referred to as Righting and Equilibrium Reactions, develop from birth up to three-and-a-half years of age. Individually and collectively, postural reflexes support higher brain centres in the *sub*conscious control of posture, balance and movement control in a gravity-based environment.

The transition from primitive to postural reflex in the first years of life should occur naturally, as maturation is 'hard wired' into the healthy developing brain, but this process is also partly inter-dependent with experience – or the environmental 'software' – through which developing pathways are entrained.

Retention of primitive reflexes beyond six months of age are recognised signs of pathology in conditions which can develop around the time of birth, such as Cerebral Palsy, or in the progress of demyelination conditions in later life, such as Multiple Sclerosis and Alzheimer's disease; but their persistence in the absence of identified pathology is still controversial. Use of the INPP screening tests has revealed that *traces* of primitive reflexes can persist in the absence of formal diagnoses, and can lead to the emergence of 'secondary symptoms' such as specific learning difficulties or under-achievement in the school-aged child and problems with emotional regulation, which can lead to the development of 'secondary' neuroses during adolescence or adult life.

Screening and Intervention

The first large independent study using the INPP Developmental Screening Test and School Intervention Programme was carried out in Northern Ireland in 2004. In a sample of 672 children assessed in six mainstream schools, 48 per cent of children aged 5–6 years and 35 per cent of children aged 8–9 years were found to have traces of primitive reflexes. When the results of the physical tests were compared to baseline measures of educational achievement, children with the highest levels of reflex *im*maturity showed lower levels of performance on educational measures.

The INPP Developmental Movement Programme was introduced in the older (8–9 year-old) group. This was carried out as a class activity for 10 minutes a day under teacher supervision over the course of one school year, and both physical and educational measures were re-assessed at the end of the year.

Children who had participated in the programme showed significant improvements in measures of neuromotor maturity and one measure of non-verbal cognitive performance compared to those who had not. There were no significant differences in educational progress between the intervention and non-intervention groups at the end of the year, but when the results of a smaller group were analysed – children who had showed signs of >25% immaturity on the neuromotor tests *and* had a reading age below chronological at the outset (the criteria for which the programme was designed) – children in this group showed increased progress on educational measures.

This study has been followed up by a series of pilot projects and formal studies in schools. In 2013, a former head teacher compared results of assessment using the INPP Developmental Screening Test with National Curriculum measures of 262 children aged 6–7 years. He found that children with the highest incidence of immaturity in neuromotor skills were all performing in the lowest quartiles on educational measures, and vice-versa.[5]

Similar findings were obtained at a school in London where the results of tests for signs of neuromotor immaturity were mapped against National Curriculum (NC) attainment: 100 per cent of pupils who scored below age-related expectations at the end of Year 2 in reading showed high (above 30 per cent) percentages of neuromotor immaturity. The lower the NC level (i.e. Level 1), the higher the average neuromotor immaturity percentage score. Pupils with the highest neuromotor immaturity (between 65 per cent and 78 per cent) scored the lowest (NC level 1) in reading, writing and maths.[6]

In a sample of 143 children across seven Jewish kindergarten schools in New York City, 48 per cent of children aged between 4.4 and 5.2 years of age were found to have >25% signs of neuromotor immaturity on the INPP Screening Test. Those children who scored higher than 25 per cent on the screening test (n=48) were found to be in the bottom third of each classroom. The schools now use the screening test as a predictive test to guide resources, including the introduction of physical intervention programmes, to help those students before failure sets in.[7]

The effects of immature motor skills are not necessarily confined to educational achievement. In one sample of 64 children assessed in primary schools in the north of England, several children had been referred to the Behavioural Support Service prior to carrying out screening tests. At the end of the first term following the introduction of the daily developmental movement programme, these children were removed from the referral list as they were no longer considered to be in need of behavioural support, although no specific behavioural work had been carried out. Furthermore, in this sample the incidence of NMI was significantly higher in the older group (7–8 years) who came from socially deprived areas, suggesting that factors associated with social deprivation such as poor housing and limited opportunity or safe outdoor spaces in which to play may be compounding factors.[8]

Other research has confirmed a link between behavioural problems in children and significant levels of motor difficulties, persistence of primitive reflexes and family upset, as well as significant literacy problems, attention deficits, and raised levels of hyperactivity/impulsivity relative to the comparison groups. Researchers concluded that these factors were all 'significant predictors of psycho-social functioning', and that 'specific movement interventions should be adopted to complement existing provision for children at risk of psychosocial problems'.[9]

The impact of social deprivation on children's physical development was investigated further in an unpublished project carried out in Scotland in 2017 involving 646 children. The INPP screening test was used alongside qualitative data from teachers, parents and children derived from focus groups and questionnaire surveys. These revealed an attainment gap in measures of physical literacy between the most and least disadvantaged. A poverty-related difference was found in the level of dysfunction when considering pupils from means-tested, low-income households (learners who received free school meals), but not for those coming from postcodes in deprived areas.

The schools introduced two different movement programmes in the school day:

1 Better Movers and Thinkers (BMT) for 537 children age 4–7 years.

2 INPP Developmental Movement Programme aged 7+ years.

At the end of the intervention, statistically significant reductions in dysfunction were detected pre- and post-screening across all sub-scales on the neuromotor tests, with the exception of visual

perceptual measures in the 4–7 year old group (BMT). In the older age-group (INPP programme), statistically significant reductions in dysfunction were detected pre- and post-screening across all sub-scales. The largest effect size was in motor sub-scales with poverty-related levels of dysfunction, seeing a complete closure of the gap on neurophysiological measures.[10]

Similar findings have been obtained from a sample of 87 children in independent schools in Russia, where 39 per cent of children in the sample obtained scores >25% (baseline score for significant indications of NMI on the screening test) with a further 4.5 per cent showing borderline results. This project also indicated that the level of NMI in boys was significantly higher at this age than in girls.[11] This raises questions are to whether a 'one size fits all' educational approach potentially places boys at a disadvantage in the first years of formal education.

An independent study which used different measures of motor proficiency indicated not only a similar significant incidence of immaturity in children's motor skills but also a possible declining trend in motor proficiency in recent years. In a sample of 120 children from both state and independent schools using the Movement Assessment Battery for Children (Movement ABC2), findings revealed a decline in performance in the following areas since the norms for the test were last revised in 2007:

> *Balance*: 43.8 (n=116). A 6.2 percentile points decline since 2007;
> *Aiming/catching*: 30.3 (n=119). A 19.7 percentile points decline since 2007;
> *Manual dexterity*: 34.2 (n=118). A 15.8 percentile points decline since 2007;
> *Overall physical development*: 31.9 (n=115). An 18.1 percentile points decline since 2007.[12]

Discussion

Many of the schools involved have reported anecdotal improvements in children's concentration and behaviour, including behaviour in the playground following use of the developmental movement programme. This may be linked to consistent improvements in children's performance on the 'draw a person test' (DAP) after participating in the programme. The DAP provides one measure of non-verbal cognitive performance. Non-verbal skills can contribute as much as 90 per cent to effective communication based on non-verbal cues such as posture, gesture, tone of voice, eye contact, social distance and knowing when to 'move in' or 'move out' of a conversation or a social group. Children with immature neuromotor skills usually under-perform on the DAP before intervention using a physical programme, with their pre-intervention drawings of the human figure indicating paucity in body awareness in specific areas related to postural and motor control. This immature physical 'vocabulary' seems to have an effect on the ability to 'read' the body language of others correctly and respond appropriately.

While much of the formal research in the last 20 years based on the INPP screening tests and assessment have focused on the incidence and impact on children in relation to learning, if these issues are not detected and remediated in childhood, associated difficulties tend to grow up with them. Intelligent children growing up in a well-regulated and supportive environment can often compensate, but the process of compensation can exact a price. This price may be paid in the onset of under-achievement, frustration, poor self-image, anxiety, exhaustion and stress with corresponding patterns of behaviour, which may initially respond to standard therapies, but which tend to re-emerge under changing conditions. Assessment of primitive and postural reflexes as markers of immaturity in the functioning of the CNS can be employed as a useful tool to indicate whether use of a physical programme would improve the outcome of other therapies.

When viewed together, findings from projects described above indicate that:

1. Immature motor skills are a significant factor in a substantial proportion of children in mainstream primary schools.
2. There is a relationship between immature motor skills and lower educational performance.
3. There appears to be a relationship between social deprivation and greater risk of children entering school with less mature motor skills.
4. Motor skills can be improved through specific developmental movement programmes introduced into schools over the course of one academic year.
5. Small samples suggest that improvement in motor skills is associated with improved educational performance in children who have *both* immature motor skills *and* who are under-achieving educationally, but larger sample sizes are needed to establish a conclusive link in the specific group.

It is also recognised that there can be many other factors involved in under-achievement, including socio-economic and emotional factors. Neuromotor immaturity is not considered to be the primary cause of the presenting difficulties, but rather a reflection of immaturity in a range of physical skills that support the formal learning process and the ability to regulate the self. As such they may be used as clinical tools with which to: recognise that physical factors are playing a part in the presenting symptoms; and identify the developmental stage from which a physical remedial programme needs to start and measure progress before, during and after intervention.

Where Do These Findings Fit in to the Concepts of Embodied Cognition and Humanistic Psychology?

The human mind is the product of dynamic interaction between the individual life force (energy) and its *relationship* with components of the self (brain and body) *and* the environment. Within this context and these continuously adapting relationships, motor actions and experience provide *one* medium through which neural pathways are developed (highways of the mind); motor abilities also reflect efficiency and flexibility in the functioning of pathways as well as being instruments of training and the primary vehicle of expression, affecting and reflecting more than simply the motor capabilities that can be observed. Human beings are indeed much more than the sum of their parts, and exist within a trinity of brain–body–spirit in the context of living. Just as nature provides the blueprint for development, so the process of living shapes the design which must adapt constantly to changing circumstances throughout the life-span.

Acknowledgement

Online presentations from the Embodied Cognition conference can be obtained by contacting info@embodiedpsychologysummit.com.

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SOME HUMANISTIC WISDOM

"A paradox arises: the only way to meaning in freedom is through boundaries. The only way that boundaries make any sense at all is through freedom."

Clark Moustakas (1923–2012)