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Direktorin des Institute for Neurophysiological Psychology INPP in Chester, GB

The Implications of Neuromotor Immaturity on Learning, Performance and Behaviour

Neuromotor skills at key stages in development provide a reflection of maturity in the functioning of the central nervous system. Studies carried out in schools in the United Kingdom between 2004 and 2019 indicate that there has been a decline in children's physical readiness for formal learning since 2004 and that immature neuromotor skills are linked to lower academic performance. The implications of these studies and other clinical findings will be explored in relation to what can be done in terms of prevention and effective remediation.

Biography

INPP was established as a private research, clinical and training organisation in 1975, dedicated to the development of assessment procedures to identify underlying physical factors in specific learning difficulties and adults suffering from anxiety and panic disorder and to the development of effective remediation programmes.

Sally is the author of seven books and other published papers on child development and neuro-developmental factors in specific learning difficulties including: Reflexes, Learning and Behavior, The Well Balanced Child, What Babies and Children REALLY Need, Attention, Balance and Coordination – the A,B,C of Learning Success - a reference source for all professionals involved in child development and education, The Genius of Natural Childhood, Assessing Neuromotor Readiness for Learning and a screening test for clinicians and health practitioners. She is also a contributor to Too Much Too Soon. Early Learning and the Erosion of Childhood and Improving the Quality of Childhood in Europe 2012.

Her clinical work also includes the use of Johansen Individualised Auditory Stimulation (JIAST) a system which uses stimulation with frequency specific music to improved auditory processing. She has both a personal and professional interest in the role of music in developing language skills.

Sally has lectured on the role of infant reflexes in development and later learning problems to many different groups throughout Europe including to a working party on child well-being at the European Parliament in Brussels and in different parts of the United States. She has also developed and standardised training in The INPP Method for use throughout the world.

She is a member of the International Alliance for Childhood and the former "Open EYE" campaign – a pressure group dedicated to ensuring that children's developmental needs remain at the top of the agenda for government recommendations for early years' education in England. She is also a patron of Toddler Kindy Gymbaroo, a programme developed in Australia to optimise children's development in the early years and a member of the educational panel for Dyspraxia awareness.

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Ihre wichtigsten deutschsprachigen Titel sind

Neuromotorische Unreife bei Kindern und Erwachsenen, Hogrefe, 1. Auflage Bern 2016
Neuromotorische Schulreife, Hogrefe, 2. Auflage Bern 2016
Greifen und Begreifen, VAK 11. Auflage Kirchzarten 2016
Warum Ihr Kind Bewegung braucht, VAK 1. Auflage Kirchzarten 2005

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The Implications of Neuromotor Immaturity on Learning Performance and Behaviour

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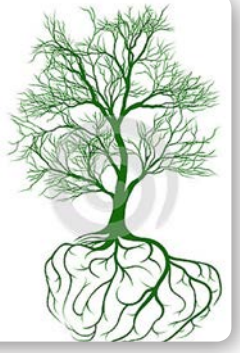
Director INPP International

Einladung zur 25. INPP Konferenz in Zürich

Learning is not all in the head

Neurological development is a complex process, which unfolds as a result of interaction between:

- genes and environment,
- maturation and experience,
- brain and body.



"A child must have one foot firmly in the known to explore the unknown" (Paynter A)

- The first years of life prepare the soil into which the seeds of information will be sown.
- Firstly through experience and secondly by the educational process absorbed through learning, to become knowledge

Embodied Cognition

- Not only does the brain control and affect the body, but the body and the the functional relationship between the two, influences the development of neural structure and function
- Thoughts, feelings and brain structure are the product of this complex inter-relationship between genes, the physical self, the environment, social relationships, opportunities and experiences

"Even our thoughts and dreams are an internalised simulation of action"

(Berthoz 2000)

In the journey from birth to walking, the seeds of language are sown.

As control of balance and posture develop, distribution of weight shifts from the front to back, freeing the hands for manipulatory skills.

Education

- Education focuses on curriculum and educational outcomes **not** on whether a child has the **developmental tools** in place to support learning.
- Assessment of neuromotor skills at key stages in development provides a means of identifying children at risk of under-achieving, as a result of immaturity in the physical skills needed to cope with the demands of the classroom.

Relationship between neuromotor skills and educational performance

Neuromotor skills support:

- Postural control and balance needed to sit still, carry out coordinated actions and free the hands from involvement in postural control, balance and locomotion.
- Fine motor skills involved in writing, cutting, articulation etc. (Babkin reflex evident in photos)
- Eye movements needed to support reading, writing, copying, catching a ball and stable visual perception
- Provide a stable physical reference point for cognitive operations in space (spatial and emotional).

What is the INPP Method?

- Established in 1975 by psychologist Peter Blythe PhD. with the aims of:
- Researching into underlying physical factors in children presenting with specific learning difficulties and adults with agoraphobia and panic disorder
- Developing reliable methods of assessing underlying physical factors.
- Developing effective and replicable systems of remedial intervention

1. INPP clinical programme

- Develops and implements physical intervention programmes using developmentally appropriate exercises (based on normal infant movement patterns in the first year of life)
- and/or
- Auditory training (IIAST) to improve the auditory processing and physical skills which are essential to support learning.

2. INPP School Programme

- Provides a manual and additional training for teachers in the use of a short screening test (15 minutes) for children from 4 years of age and upwards.
- How to use the INPP Developmental Movement Programme for whole classes or selected groups of children in schools (7+ years)

- Goddard Blythe SA, 2012*(Assessing NMR for Learning*. Wiley-Blackwell.

INPP School Programme: Assessments of Motor Development

INPP Screening test includes: (15 minutes)

- Tests for the presence of 3 primitive reflexes, which have consistently been found to play a part in educational under-achievement
- Tests for "soft signs" of neurological dysfunction
- Signs of dysdiadochokinesia
- Tests to identify signs of oculo-motor, visual perceptual and auditory processing difficulties
- (Use of the draw a person test as one independent measure of non-verbal cognitive performance)
- Additional independent measures used in schools may include national curriculum measures of reading, writing and numeracy.

Why is there a need?

Increasing professional specialisation has resulted in:

- Medicine – focuses on the diagnosis and treatment of disease versus dysfunction.
- Transfer of responsibility for the area of special needs from Medicine to Education in the 1980's (UK) meant that developmental checks are no longer carried out at school entry or at key stages in education.
- Teachers – not trained in stages of physical development and the relationship between physical development and cognitive performance
- Education Psychologists – trained in assessment of cognitive skills but not the physical underpinnings and supervision of physical remediation programmes - intervention (including sensory training)
- Children with NMI frequently fall through the gaps between these professional domains

Neuromotor skills and educational performance

The first five years of life have been shown to be crucial for motor, cognitive and social-emotional skills (Sheridan et al 2010, Kirk and Rhodes 2011).

Levels of motor behaviour at key stages in development is a critical factor in child behaviour (Schöner and Thelan 2006)

Studies have indicated that motor proficiency in 5 – 6 year olds was associated with performance on cognitive tasks involving attention and areas of executive functioning (Wassenberg et al. 2005)

Motor development in the first year of life may predict later learning outcomes and social behaviour at 5 years. Hansen et al. (2010)

- Inability to reach milestones such as sitting upright or crawling is linked to learning and behaviour problems.
- Youngsters who struggled with the tasks had a significantly increased risk of falling behind at school when they were five.
- They were also more likely to demonstrate anti-social behaviour such as refusing to share.
- Researchers concluded developmental delays affected about 10 per cent of children

(These findings come from the Millennium Cohort Study, which is looking at 18,818 babies born between 2000 and 2001. Researchers, who tracked 15,000 children over the first five years of their lives, said a simple screening test before a child reaches their first birthday could prove crucial in preventing youngsters falling behind)

Meta-analytic review of research literature examining motor impairments in children with speech and language impairments:

Rechetnikov RR, 2008. http://utdr.utoledo.edu/graduate-projects

Deficits in speech and language disorders were associated with motor impairments.

Recommended that additional tests (motor performance) be added to the assessment of children being assessed for specific language disorders.

"In therapeutic setting, occupational therapists should advocate for integrated assessment and treatment plans with SALTs when a speech and language impairment is suspected.

Neuroplasticity

Can physical intervention programmes help?

- Decades of research have shown that substantial changes occur in the lowest neocortical processing areas, and that these changes can profoundly alter the pattern of neuronal activation in response to experience (Chane and Warren 2007).
- Neuroscientific research indicates that experience can actually change both the brain's physical structure and functional organization.

Neuromotor skills as reflections of maturity in CNS functioning

- These findings do not mean that motor impairments are the primary *cause* of the associated difficulties
- They are, however, a factor which may be amenable to developmentally appropriate remedial intervention impacting more than simply motor skills.

Neuromotor Immaturity – Definitions

Neuromotor immaturity (NMI) describes the retention of immature patterns of movement control. These may occur as a result of:

Classical neurological signs (pathology) or

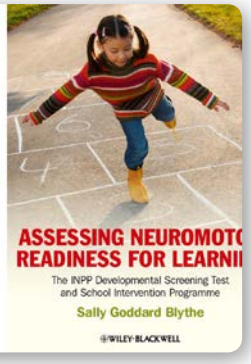
Be reflective of a functional or developmental delay in the pathways involved.

Neuromotor Immaturity (NMI) INPP Definition

- Persistence of primitive reflexes in children above 6 months of age
  with or without
- Absent or under-developed postural reflexes (reactions) above 3½ years of age

Assessing Neuromotor Readiness for Learning
Screening tests for 4 – 7 years and 7+ years

- 0 – 4 rating scale on each test:
- 0 = NAD
- 1 = 25% dysfunction
- 2 = 50% dysfunction
- 3 = 75% dysfunction
- 4 = 100% dysfunction
- Individual total /4 on every test = % of immaturity.
- A total of >25% indicates a degree of NMI likely to interfere with performance



Is NMI present in the general school population? (2004, 2005)

School	Number of Participants	Age Range	Incidence of NMI	Source
NEELB N. Ireland. 2004	672	5- 6 years 8 – 9 years	48% 35%	www.neelb.org.uk. Child Care in Practice.2005. 11/4:415-432.

Does NMI respond to a daily developmental programme carried out in school every day?

Schools	Results	Source
NEELB. Northern Ireland	✓Significant improvements in NM measures in exp. group compared to control. ✓Significant improvement in "draw a person" test (non-verbal cognitive performance) ✓Children who had >25% NMI and educational under-achievement at the outset made greater gains on educ. Measures. Numbers involved too small to reach statistical significance	North Eastern Education Library Board (NEELB) 2004. An evaluation of the pilot INPP movement programme in primary schools in the NEELB Northern Ireland. Final report. Prepared by Brainbox Research. www.neelb.org.uk Goddard Blythe SA. 2005. *Child Care in Practice.* 11/4:415-432

Is there a link between NMI and educational achievement?

School	N	Age range	Incidence of NMI	Source
Midlands	262	6 – 7 years	Correlation between NMI and achievement using National Curriculum levels. Children with lowest incidence of NMI were in the highest achieving quartiles on SATS and vice-versa	www.open-doors-therapy.com

Links between NMI and attainment

School	Participants	Incidence of NMI
John Stainer Community School, London. Presented at: The Child Development in Education Conference. Royal Society of Arts. London. October 2014 Harte S, 2014.	Year 3 pupils who had scored below age related expectations at the end of Year 2 in reading (National Curriculum levels of achievement)	✓ 100% of pupils who scored below age related expectations at the end of Year 2 in reading, showed high (above 30%) percentages of neuromotor immaturity. ✓ The lower the NC level (ie Level 1), the higher the average neuromotor immaturity percentage score. ✓ Pupils with the highest neuromotor immaturity (between 65% and 78%) scored the lowest (NC level 1) in reading, writing and maths

Kindergarten schools in New York City (Dubin S, 2015)

School	Number of Participants	Age range	% with >25% signs of NMI	Outcomes
7 kindergarten classrooms in New York city. 7 Kindergarten Classrooms n = 143		4.4 – 5 .2 years	48/143	Those children who scored higher than 25% on INPP screening test (n=48) were found to be in the bottom 1/3rd of each classroom. We now use the battery as a predictive test to guide resources to help those students before failure sets in.

Is there a decline in children's physical readiness for learning since 2004/5?

Local Education Authority (Ongoing independent project)

School	Number of Participants	Age Range	Incidence of NMI	Source
LEA Scotland 2018	646	248 (4-7) 393 (7+)	4-7= 204 (82%) 7+ = 312 (79%)	LEA Scotland
Interventions: Physical Active Health Project – Scottish Attainment Challenge	537 BMT only 109 INPP intervention	38 (4-7) 71 (7+)	Awaiting Phase 2 results	

Decline in children' s neuromotor skills?

Phase 1 of the LEA project indicates a possible 30% decline in markers of NM maturity since the same screening test was used on a similar sized sample in 2004.

A smaller project using the Movement ABC2 assessment of motor proficiency suggests a smaller, but nevertheless declining trend.

Baseline Data (Loughborough Project)
Movement ABC

(Preedy P, Duncombe R., www.movement4learning)

In 2007 when the **Movement ABC-2** was produced and the data normalised, the mean would have been 50 (based on a normal distribution). The M4L data show declines from this in all areas tested:

- Balance: 43.8 (n=116)
  - 6.2 percentile points worse than in 2007
- Aiming/catching: 30.3 (n=119)
  - 19.7 percentile points worse than in 2007
- Manual dexterity: 34.2 (n=118)
  - 15.8 percentile points worse than in 2007
- Overall Physical development: 31.9 (n=115)
  - 18.1 percentile points worse than in 2007

NMI and Speech Development
Is there a relationship?

Analysis of 45 case studies seen at INPP

Criteria for inclusion
All had received SALT several years prior to being seen at INPP

Factors which *might* be involved:

- Postural
- Manual and oral dexterity (fine motor)
- Auditory
- Role of non-verbal skills in supporting verbal communication

Children who had previously received Speech and Language Therapy (SALT)

N = 45
M = 33
F = 12
Age range 6 – 14 years

N with **additional** diagnosis = 25
Several subjects had received more than one diagnosis

Additional Diagnosis	N
ADHD	5
ADD	2
APD	1
ASD	3
DCD	7
Dyslexia	6
SI	1
DAMP	1
Selective Mutism	2

Factors included for analysis:

1. Late learning to walk;
2. Late learning to talk
3. History of frequent ENT in first 3 years;
4. Dysdiachokinesia – fingers, hands and feet.

Reasons why criteria included:

1. Indicative of delay in achieving postural control.
2. Delayed speech.
3. May affect development of auditory discrimination, selective attention to auditory stimuli and speed of auditory processing.
4. Adjacent areas of the brain involved in individual finger movement and fine motor control of the mouth.
5. Ability to use left and right sides independently can be linked to postural control.
6. Postural control implicated in the development of lateral preference (Kohen-Raz 1986), considered to be a precursor to fluent language development.

Role of the Hand in the Evolution of Language

- Gesture and referential pointing precede speech (mime)
- Freeing of the hand from postural control and locomotor functions, and development of manipulative skills important in the evolution of language
- Mouth and hand are two related movement systems that start out coordinated with one another (early feeding), but must become uncoupled for the development of fluent speech.
- Adjoining areas of the brain involved in fine motor control of the fingers involved in fine motor control of the lips and tongue. Areas involved in language (Broca) are also activated during motor tasks (Bonda et al. 1994) and when visualising motor tasks (Krams et al 1998)
- Children where hand and mouth movements remain coupled (above 6 years of age) often have difficulties with fine motor skills (handwriting) and a history of earlier speech related problems.

Tactile Reflexes

Tactile reflexes effecting the hand and mouth:

- Palmar reflex
- Plantar reflex
- Rooting
- Infant suck reflex
- Babkin reflex

Implications for Speech and Language development:

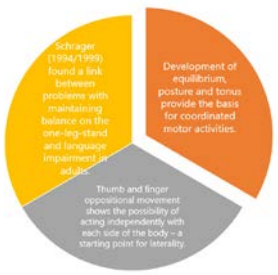
- Initially hands and mouth and feet are connected in feeding (suck, plantar and babkin reflexes);
- Use of hands and mouth need to be become uncoupled for more sophisticated use of gesture and speech to progress, and the feet for postural control.
- Can the persistence of these reflexes interfere with, or be linked to the development of fine motor skills involved in speech production?

Vestibular reflexes linked to postural control

- TLR
- Moro
- Oculo and Labyrinthine Head Righting Reflexes (OHRR and LHRR)
- (ATNR)

Retention of these reflexes is *not* the cause of speech problems but is indicative of immaturity in the functioning of the CNS with particular effect on balance and postural control.

What might the implications of balance and postural control be for speech development?



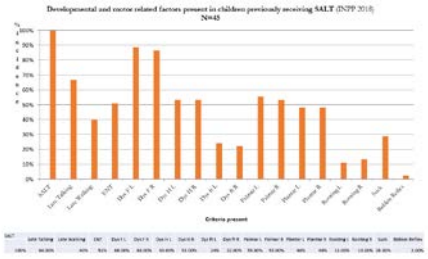
Why might postural control support speech?

Bipedal man stands on
4 points:
2 forefeet
2 heels
(Kohen-Raz 2004)

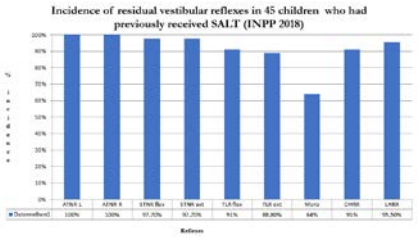
Why might postural control support speech?

- As postural control develops,
- Forefeet increasingly take over the function of the hands in supporting the body from quadruped to biped locomotion freeing the hands to develop manipulative skills.
- The heels take over the function of the forefeet and knees.
- Transition from quadruped to biped (postural field independence) mirrored by development from dorsal posture skin reaction to the front of the body, particularly the "liberated arms" and hands (Peiper 1963) freeing the hands for manipulative actions.
- Volume control is linked to diaphragmatic control of breathing – linked to upright posture.

Analysis of developmental and motor factors in children who had received SALT (Goddard Blythe 2018)



Incidence of residual vestibular reflexes in children who had received SALT(Goddard Blythe 2018)



Evidence of immaturity on one measure of non-verbal language - Draw a Person (DAP) test (children with a history of having received SALT)

Why might non-verbal performance be linked to speech?

Up to 90% of effective communication is based on the non-verbal aspects of language

For effective communication it is necessary to be able to reflect non-verbal and verbal aspects of communication. Motor skills are one element, or part of the "vocabulary", of non-verbal communication.

Developmental Norms

Children who are delayed in their physical development need **more** time involved in **general physical activities** before being ready to integrate fine motor and visual integration tasks

1. 1 Leg Stand
   3 ½ - 4 years – 8 seconds
2. Thumb and finger opposition develops from
   5½ - 6 years
3. Crossing the midline
   4 years

Why might exercises aimed at improving posture, balance and proprioception impact visual perception and language?

- Postural stability provides a firm foundation in a gravity based environment for brain centres involved in the control of eye movements, which support visual perception and for motor coordination.
- Postural stability and autonomy (suppression of synkinetic movements and awareness of body laterality) is an important criterion for psychomotor readiness for school (de Quirós 1978)
- Establishment of an articulate and fluent physical (non-verbal) vocabulary supports verbal language and the ability to "read" situations and regulate response to social situations.
- Language is inseparable from imagery (the ability to visualise actions with the mind's eye) and gesture. Imagery is rooted in awareness of body schema and the ability to differentiate the self from the environment.

Neurophysiological aspects of postural control

- Spinal level – interaction of the body with the environment generating forces which counteract gravity and deal with obstacles and resistance to surroundings
- Vestibular-spinal-cervical-oculomotor circuits – regulates information processes involved in displacement in space and vice-versa enabling differentiation between objective and subjective steadiness and motion.
- Cortical level - uses background tonus and executive programmes to perform complex intentional motor acts
- Cerebellar level – interlinks with numerous circuits and relays which monitor minute temporal and spatial sequences of elaborate response patterns.

What needs to be done?

1. Further rigorous large scale academic and independent research into the relationship between motor skills, educational performance and speech delay.
2. Developmental screening (physical) of all children at the time of school entry and at key stages through education.
3. Implementation of effective (researched) daily physical programmes into schools.
4. Improved awareness and education of parents, and *training* to teachers, trainee teachers clinicians and teenagers (parents of the future) of the importance of physical development in childhood to support learning.
5. Improved inter-disciplinary communication and cooperation (Medicine and Education) from birth throughout the school years in the assessment and provision of remedial interventions for children with a range of presenting problems, including under-achievement.

Ongoing Projects:
Russia – NMI Screening
Yorkshire Schools – NMI Screening

Participants	NMI Screening
Russia 8000 children; 45 regions; aged 4 – 7 years	Russian government education using the screening test with children entering school (in Russia this age is six). Results pending
UK Sheffield Early Years 1 school (Moorbrook)	140 children – F2, Y1 and Y2. Started a combination of exercises from *Movement – Your Child's First Language* and songs from *Wings of Childhood* with children selected as having >25% NMI and or children for whom teachers have concerns. "We are currently using *Movement – First Language* with some of our F2 and Y1 pupils, following training in Sheffield last Summer. We are now thinking that we would like to move forward as a whole school with this, as we have seen the progress the children are making with their coordination and control"

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