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NEW WRITING

Neuro-motor maturity – an indicator of developmental readiness for education

Sally Goddard Blythe

Sally Goddard Blythe is the Director of the pioneering Institute for Neuro-Physiological Psychology (INPP) in Chester. (www.inpp.org.uk) She has worked in the area of neuro-development for more than 20 years and is the author of several books and published papers on child development and neurodevelopmental factors in specific learning difficulties including *Reflexes, Learning and Behavior, What Babies and Children Really Need, Attention, Balance and Coordination – the A,B,C of Learning Success,* and *The Genius of Natural Childhood.* Sally is the author of *The INPP Screening Test and Developmental Programme for Use in Schools*, which has been piloted with several thousand children across the world and is due to be published by Wiley-Blackwell in 2012.

Summary

Despite initiatives of successive governments there remains a significant percentage of children whose mastery of basic skills continues to fall below expected levels at the end of primary education with children from poorer backgrounds being at a particular disadvantage. One area that has not received sufficient attention in recent years is developmental and physical 'readiness' for formal education.

One method of observing a child's physical development is through the assessment of primitive reflexes, postural reactions, balance and co-ordination. Primitive reflexes and postural reactions provide useful tools in this respect because there are key stages in development when primitive reflexes should be active, suppressed and transformed into mature postural reactions. Reflex status viewed in the context of a child's chronological age can provide a reflection of maturity in the functioning of the individual child's central nervous system and indications of maturity in the neuro-motor skills needed to support all aspects of cognitive learning.

This essay discusses the findings from the use of a screening test for neuro-motor immaturity in schools in the United Kingdom and the impact of a daily developmental movement programme introduced into schools.

Introduction

There can be many reasons why a child fails to attain competence in literacy and grapho-motor skills, some of which are already addressed by services within the education system and initiatives to support development in the early years. Nevertheless, there remains a significant percentage of children whose mastery of basic skills continues to fall below expected levels at the end of primary education (Ofsted, 2010[1]) with children from poorer backgrounds being at a particular disadvantage (Goodman and Gregg, 2010[2]). One area that has not received sufficient attention in recent years is developmental and physical 'readiness' for formal education.

Readiness for school requires much more than a child simply reaching the chronological age required for school entry. To perform well in an educational environment, a child needs to be able to sit still, pay attention, use a writing instrument, and to control a series of eye movements – which are necessary to follow a line of print without the eyes 'jumping' or losing their place on the page. These are physical abilities, which are linked to the development and maturation of motor skills and postural control. Growth and physical development are as important to education as they are to the field of developmental medicine but have been largely overlooked by the educational system since the phasing out of routine developmental tests for all children which, until the 1980s, used to be carried out by the school doctor at rising 5 years of age.

One method of observing a child's physical development is through the assessment of primitive reflexes, postural reactions, balance and co-ordination. Each child's brain is designed to follow an orderly, predictable inter-related sequence of development, facilitated through maturation and entrained through interaction with the environment. Thus, aspects of a child's development may be inferred from his or her motor skills. Primitive reflexes and postural reactions provide useful tools in this respect because there are key stages in development when primitive reflexes should be active, suppressed and transformed into mature postural reactions. Reflex status viewed in the context of a child's chronological age can therefore provide a reflection of maturity in the functioning of the individual child's central nervous system.

What is a reflex?

A reflex is an automatic, instinctive, unlearned reaction to a stimulus, which is carried out without volition or conscious control with the same stimulus always evoking the same stereotyped response. Well-recognised examples of reflexes include the automatic constriction of the pupils of the eye in strong light or the knee jerk in response to tapping of the knee.

Primitive reflexes are a particular group of reflexes which are only present in the first few months of life and diminish as the central nervous system of the infant matures**.** Primitive reflexes develop during life in the womb, are active for the first few months after birth and then gradually recede as connections to higher centres in the brain develop. Examples of primitive reflexes include reflexes for sucking, grasping and responding to changes of position.

Primitive reflexes are significant because the presence or absence of primitive reflexes at key stages in development provide acknowledged signposts of maturity in the functioning of the central nervous system. While doctors, midwives and health visitors are familiar with assessment of the primitive reflexes at birth and tests for primitive reflexes are repeated at developmental check-ups in the first six months of postnatal life, these tests are not repeated in the pre-school or school-aged child if development appears to be progressing normally.

Primitive reflexes never entirely disappear but become inhibited as ‘higher’ centres in the brain mature in the first months of life. Primitive reflexes can remain active if there has been damage to higher centres in early life, such as in cerebral palsy, or if there is accident or damage to higher brain centres in later life, for example after a stroke, head injury or in degenerative diseases of the central nervous system such as multiple sclerosis or Alzheimer’s disease. According to medical theory, primitive reflexes should not remain active in the general population beyond 6 months of age and if elicited beyond this age are usually considered to be indicative of underlying pathology.

However, there is an increasing body of evidence which suggests that *traces* of primitive reflexes (residual reflexes) can remain active in the general population in the absence of identified pathology (McPhillips et al. 2000[3]; Goddard Blythe, 2001[4]; McPhillips and Sheehy, 2004[5]; Taylor et al. 2004[6]; Goddard Blythe, 2005[7]; McPhillips and Jordan-Black, 2007[8]). Residual presence of primitive reflexes in children above the age of 6 months can therefore provide indications of **neuro-motor immaturity**, which individually and collectively act as barriers to learning.

Assessment of primitive reflexes beyond the first 6 months of life provides the clinician or educator with tools with which to:

1. Identify signs of neuro-motor immaturity (Identification).
2. Assess the type and level of intervention which is appropriate for the child (Intervention/Remediation).
3. Measure change in reflex status before and after intervention (Evaluation).

What is the significance of neuro-motor maturity to education?

The Millennium Cohort Study is a longitudinal study tracking the progress of nearly fifteen thousand children who were born in the United Kingdom between 2000 and 2001 (The Millennium Cohort Study[9]). Findings released in February 2010 showed that children who failed at nine months to reach four key milestones in gross motor development (relating to sitting unaided, crawling, standing and taking their first steps) were found to be five points behind on average cognitive ability tests taken at five years of age compared to those who passed the milestones. 'Delay in gross and fine motor development in a child's first year, was significantly associated with cognitive development and behavioural adjustment at five'[10].

What effects can immature reflexes have on development and learning?

Abnormal primitive and postural reflexes in the older child can affect functioning in many different ways as follows:

- Control posture when standing, sitting or moving.
- Balance.
- Ability to sit still.
- Co-ordination and motor skills.
- Control of eye movements needed for reading.
- Hand-eye co-ordination needed for writing and drawing.
- Spatial skills and organisation.
- Concentration.
- Emotional functioning.
- Behaviour including impulse control.

Children with *partially* retained primitive reflexes tend to reach developmental milestones at approximately the normal time and are often overlooked during standard medical screening tests in the first year. Signs of difficulty only begin to emerge when they start formal schooling when 'symptoms' such as difficulty in learning to read or write, general restlessness or immature behaviour appear but do not point directly to the underlying causes.

Some of these children may go on to be diagnosed as having a specific learning difficulty such as dyslexia, developmental co-ordination disorder (formerly *dyspraxia*) or attention deficit disorder. Others are able to use their intelligence to compensate for the underlying difficulties but tend to underachieve in the classroom. A third group start to develop a variety of behavioural or emotional problems which result from a combination of frustration, poorly developed self-regulatory skills and inability to match performance to intelligence – resulting in underachievement in the classroom or on the sports field, or in problems with social integration. One such child was described by his parents as, 'being 10 years old on the outside but only 3 years old on the inside'.

What is the impact of retained primitive reflexes on learning?

Each reflex has been identified as playing a part in specific aspects of learning and behaviour (Goddard, 1996[11]; Goddard Blythe, 2008[12]) but when neuro-motor immaturity is present in a school-aged child several reflexes (a *cluster*) are usually involved before symptoms start to show up in the classroom. A few examples of individual reflexes and their effects are described below:

1. The Asymmetrical Tonic Neck Reflex (ATNR)

The Asymmetrical Tonic Neck Reflex (ATNR) is elicited by rotation of the head to either side, which results in extension of the arm, hand and leg on the side to which is the head is turned and flexion of the opposite (occipital) limbs (Fig. 1).

Fig. 1: The ATNR in the first month of life

If the ATNR remains active in a school-aged child, it can interfere with control of upright balance because turning of the head causes the arm and leg on one side of the body to straighten while the opposite limbs bend, upsetting control of balance. It can also interfere with control of the arm and hand when the head is turned to one side, ability to cross the midline of the body[13] affecting left-right integration (DeMyer, 1980[14]; Holt, 1991[15]), control of the hand when writing (Blythe & McGlown, 1979[16]), and the visual skills necessary for reading such as visual tracking (Goddard, 1995[17]; Bein-Wierzbinski, 2001[18]).

2. The Symmetrical Tonic Neck Reflex (STNR)

While the ATNR influences muscle tone on either side of the body, another reflex, the Symmetrical Tonic Neck Reflex (STNR), affects how the upper and lower sections of the body function together. The STNR emerges at approximately 5 - 8 months of age – just as the infant is getting ready to push himself or herself up on to hands and knees to crawl. Flexion of the head causes the arms to bend and the legs to straighten (Fig. 2); conversely, extension of the head results in straightening of the arms and bending of the legs (Fig. 3).

Fig. 2: STNR in flexion

Fig. 3: STNR in extension

(Figs. 2 and 3 from *The Genius of Natural Childhood*, Hawthorn Press, Stroud. Due to be published July 2011)

If the STNR has not been suppressed in the school-aged child it can affect posture when sitting or standing, the ability to sit still, and the muscle tone and co-ordination needed for activities such as learning to swim and doing forward rolls. Other researchers have found a link between retention of the STNR and Attention Deficit Hyperactivity Disorder (ADHD) (O'Dell and Cook, 1996[19]) and problems with speed and accuracy of copying (Blythe and McGlown, 1979[20]).

3. Head-righting Reflexes (postural reactions)

Retention of primitive reflexes can also affect the development of subsequent postural reactions, such as head-righting reflexes – essential for the maintenance of proper head alignment in relation to body position, upright head and body posture and control of eye movements (De Quiros and Schrager, 1978[21]; Kohen-Raz, 1996[22]). Head-righting reflexes operate in response to change in body position, automatically correcting the head position to the midline. Not only does this automatic righting reaction facilitate good maintenance of balance but head position also provides the reference point from which centres involved in the control of eye movements take their cue. If head alignment is off-centre, then eye movements will also be impaired. This can affect reading, writing, copying and operations in space.

4. The Palmar Grasp Reflex

While the ATNR, STNR and head-righting reflexes are all examples of reflexes which operate through the balance mechanism, reflexes which respond to touch stimuli can also have an impact on learning outcomes. The palmar reflex is one example of this. If the palm of a new-born baby’s hand is touched, the thumb closes inwards and the fingers close on top forming a grasp, which in theory, is strong enough to hold the entire weight of the neonate. (Fig. 4).

Fig. 4: The infant palmar grasp reflex

Retention of the palmar reflex beyond the first few months of life can interfere with the development of the thumb and finger opposition movements, which are necessary to form a ‘pincer’ grip and the ability to use each finger independently. This can interfere with the ability to form a good writing grip (Fig. 5) and can sometimes be linked to a history of speech problems. Speech can be affected by this simple reflex because the same centres in the brain responsible for the control of fine finger movements are also involved in motor movements of the lips, tongue and cheek muscles required for the motor aspects of speech.

Fig. 5: Writing grip characteristic of a child with a residual palmar reflex

How are reflexes integrated in the course of normal development?

In the normal developing child, the transition from primitive reflexes to postural reactions takes place as a result of two processes working together – maturation within the central nervous system and interaction with the physical world. In the first six months of life the formation and strengthening of connections between lower and higher centres in the brain take place at a rapid rate, enabling the cortex to have increasing control over planning of purposeful movement and flexibility of response to sensory stimuli. At the same time, muscle tone and control of movement increase, rendering primitive, automatic and stereotyped reflex responses redundant. These interactive processes also require physical experience, repetition and practice to develop. Reflex integration is therefore a gradual process which takes place in the context of normal development in the first year(s) of life in conjunction with movement experience.

Primitive reflexes also have a role in early development. Some reflexes such as the ATNR and spinal Galant reflex are thought to assist in the birth process. Others, such as the rooting and suck reflexes, enable a child to feed at birth, while the Moro reflex acts as the infant's arousal and fight/flight reaction to aversive stimuli. Reflexes also provide a ready-made repertoire of unconscious reactions to sensory stimuli before connections to higher centres in the brain have developed, ensuring that the infant responds to certain stimuli. This is important because ***movement is the primary medium through which sensory integration takes place.***

Early feeding reflexes provide an example of this. If the area around the side of the mouth is gently stroked shortly after birth, the new born baby will turn its head and using touch, will try to nuzzle, search or 'root' for the breast (a similar type of action to a cat rubbing itself against its owner's legs when it wants to be fed). Initially, it is the senses of touch and smell which lead the new-born to the breast, and when the roof of the baby's mouth makes contact with the breast, another reflex will automatically stimulate sucking movements. If breastfeeding is successfully established, within only a few weeks, *sight* of the breast will be sufficient to stimulate sucking movements. In other words, touch, smell and motor action lead into visual recognition.

A different example can be seen during integration of the Symmetrical Tonic Neck Reflex. The reflex helps the infant to get up off the ground from the prone to a four point kneeling position in readiness for crawling. However, as long as the STNR persists, movement of the head up or down will cause one end of the body to collapse, preventing the infant from being able to crawl. Most babies go through a brief phase of 'rocking' on hands and knees, which helps to integrate the reflex so that a few days later the infant is able to put its head up and maintain control of the upper and lower sections of the body. The reflex has helped one stage of development, but spontaneous movement is necessary to facilitate the next. The action of crawling on hands and knees is also important as it co-ordinates use of balance, upper and lower body, left and right sides and the visual system all at the same time. The hand-eye co-ordination that takes place during crawling is at the same relative visual distance that a child will use a few years later to read and write and may be an important stage in training later visual-motor integration.

Why do primitive reflexes persist in some children?

The traditional view still prevails that retention of primitive reflexes beyond the first six months of life is a sign of pathology. However, as discussed at the beginning, more subtle signs of residual primitive reflexes can and do exist in the general population in the absence of a medical diagnosis. A developmental screening questionnaire, devised at The Institute for Neuro-Physiological Psychology (INPP) in Chester, which has been in use for more than 30 years, has consistently shown that if there is a *cluster* of factors in early development such as medical problems during pregnancy, birth and delay in development during the first 12 months of postnatal life, a child is more likely to have retained immature reflexes which interfere with learning outcomes (Goddard Blythe and Hyland, 1998[23]).

Empirical evidence from clinical observation in the last 10 years suggests that these underlying physical factors may be compounded by lack of environmental opportunity in the early years needed to develop physical skills. Such factors would include overuse of baby equipment resulting in lack of free, unrestricted movement (floor play) in the first year of life and over-reliance on electronic media rather than one-to-one physical interaction to keep babies entertained. While these observations need more evidence to support them, there is a risk that as technology advances, new generations of parents and carers are unaware of the importance of physical experience in the early years to support later learning.

Can anything be done to improve neuro-motor immaturity in the older child?

In many cases immature primitive reflexes can be inhibited and postural reactions can be developed with the use of physical intervention programmes. These programmes can be used with individual children in a clinical setting or with groups or a class of children in schools.

In 1996, Goddard Blythe compiled a developmental test battery which could be administered by teachers in school and a developmental movement programme to be used with a class of children every day over the course of one academic year. Access to the test battery and developmental movement programme was through an INPP one-day training course. This programme has been the subject of a number of independent studies, which have consistently shown that:

1. Primitive reflexes are present in children in mainstream schools.
2. Retention of primitive reflexes is linked to lower educational achievement.
3. Retention of primitive reflexes is linked to lower performance on one measure of non-verbal cognitive performance (the Draw-a-Person Test).
4. Children who took part in the INPP programme for schools showed greater decrease in abnormal reflexes than children in control or comparison groups.
5. There was a correlation between decrease in retained reflexes and increase in performance on the Draw-a-Person Test (North Eastern Education Library Board Report[24]).
6. When more than 25% abnormality was present in retained reflexes *and* reading age of more than 6 months below chronological age at the outset, children who followed the INPP developmental movement programme made greater improvements in reading

after completing the programme than the comparison group who did not participate in the daily developmental movement programme. (Goddard Blythe, 2005[25]).

Other reported findings from teachers in schools where the programme has been used include the following:

- Improvements in playground behaviour.
- Children are quicker to settle down to lessons following the daily movement sessions.
- Handwriting improves and children report finding it easier to write.
- Improvements in reading.
- Improvements in children's posture, poise, co-ordination, confidence and consideration for others.

In one area where 5 children had been referred to the behavioural support service (but had not yet received support from them), at the end of the first term on the programme all 5 children had been removed from the referral list despite no behavioural intervention having been used.

The theory of replication

The INPP programmes are not the only physical programmes available to address problems associated with retention of primitive reflexes and immature postural reactions, but results from the INPP programmes have consistently shown them to be effective in improving the neuro-motor skills of children with neuro-motor immaturity. Movements in these programmes are based upon Blythe's theory of *replication.* This theory advocates that just as normal movements during infancy facilitate integration of the primitive reflexes into postural reactions, so these movements can be replicated at any time in development to assist in the rehabilitation of neurological impairment or encourage the development of neuro-motor skills.

Just as in infancy these movement patterns are practised many times in the first year(s) of life, so any intervention programme based on this theory depends on 3 factors to succeed: regularity, repetition and duration. For this reason developmental movements have been selected in an orderly sequence and are practised every day for a period of up to 6 weeks before moving on to the next exercises in the sequence. The programme is used for 5 - 10 minutes per day for one academic year.

Conclusion

Results from use of the programme in schools to date indicate that neuro-motor immaturity is a significant factor amongst a substantial percentage of children in mainstream schools. While there can be other and additional reasons for underachievement, the assessment of neuro-motor maturity can help to identify underlying causes and lead to physical intervention programmes that can help to improve underlying mechanisms and support additional teaching initiatives and strategies in the classroom. To continue teaching without first providing a child with the necessary tools for learning is like trying to build a house from the top downwards. At every stage in life, physical skills provide the foundations and the channels through which knowledge is expressed.

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