Reflections of brain-body functioning

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Abstract

The presence of primitive and postural reflexes at key stages in development provide reliable indicators of maturity in the functioning of the Central Nervous System. Primitive reflexes are tested routinely at birth and in the first few weeks of postnatal life but are not re-assessed at a later age as a matter of course. This paper examines the functions and effects of three primitive reflexes, explaining how abnormal primitive reflexes can predispose a child to allergy, anxiety, coordination problems and subsequent learning and behavioral challenges including inattention.

Keywords: learning disability, neurological dysfunction, postural reflexes, primitive reflexes

1. Introduction

At the moment of birth, a baby is assailed by a plethora of novel sensations: Light to stimulate the eyes, sounds that are no longer filtered through the abdominal wall and surrounding fluid, smells, skin contact, change of temperature and the full force of gravity.

Nature has equipped him to respond to some of these sensations with a set of primitive reflexes, which provide rudimentary reactions to key stimuli and which also help to train the foundations for many later motor skills. These reflexes have protective, survival and integrative functions in the early months of life, but should be gradually inhibited by the developing brain in the first 6 months of postnatal life. In the first 3½ years of life the primitive reflexes are replaced by more advanced postural reflexes, which provide the basis for automatic control of posture and movement in a gravity based environment.

If primitive and postural reflexes fail to mature at the expected time in development, they are said to be aberrant and they represent a structural weakness in the functioning of the Central Nervous System. Aberrant reflexes are used for diagnostic purposes as evidence of damage to higher centres in the brain in pathological conditions such as Cerebral Palsy and in demyelination diseases such as Multiple Sclerosis and Alzheimer's Disease.

There is an increasing body of evidence to support the theory that abnormal primitive and postural reflex activity also exist within the general population as well as in cases of identified pathology [1-8]. Many of the signs and symptoms of aberrant reflexes fall under different diagnostic categories such as Developmental Coordination Disorder, Attention Deficit Disorder, Asperger's Syndrome and the Autistic Spectrum Disorders, which describe a cluster of different symptoms that a number of years ago might have been described collectively under the more general and now redundant term of Minimal Brain Dysfunction (MBD).

Abnormal primitive and postural reflexes can affect many areas of functioning including: Balance, gross and fine muscle coordination, speech, eye movements, visual perception, auditory processing, immune functioning and behaviour.

A more detailed description of individual reflexes will help to illustrate how lack of reflex integration in the early years can affect many functions later on.

2. The Moro reflex

The Moro reflex emerges at between 9 and 12 weeks after conception. It continues to develop during pregnancy and should be present in the full term infant (40 weeks gestation). Named "umklammerung reflex" by Moro [9], meaning the "clasping reflex", it describes the infant's response to any sudden unexpected event, particularly loss of support to the head.

If the baby's head is lowered rapidly below the level of the spine, arms and legs open out (abduct), there is a rapid intake of breath and the baby "freezes" in that position for a fraction of second, before arms and legs return across the body and the baby exhales, often with a cry of protest.

The Moro reflex provides an immediate arousal mechanism, which activates the primitive fight/flight reaction and also stimulates the breathing centre in the brain.

By 4 months of age the Moro reaction should be modified so that if there is a sudden or unexpected event, the baby "startles", raises its shoulders and starts to search the environment to seek out the source of danger (orientation). Provided the infant has the means to respond appropriately to the source of alert, it will either react to the stimulus (attention), or ignore it (filter unwanted stimuli out of conscious awareness). This later reaction pattern forms the basis of the adult startle response and indicates increased maturity within the nervous system as well as forming a basis for selective attention.

If the Moro reflex persists beyond its normal period of activity (4 months of life), it is associated with increased sensitivity and reactivity to sudden unexpected stimuli: Sudden loss of balance, postural instability or unexpected stimulation of any one of the senses can release the Moro reflex from cortical control. This is important because the Moro reflex does not allow time for the *conscious* brain to analyse the situation and direct

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an appropriate response. Instead, the system goes into emergency mode as the Moro reflex acts as the primitive fight or flight reaction. In other words, the child reacts first, and thinks afterwards – a major ingredient of impulsive and inappropriate behaviour.

The Moro reflex is particularly significant because it can be activated by any one of the sensory systems, although after birth it is most sensitive to over-stimulation of the balance mechanism and sudden loud noise [10].

2. 1 Functions

The functions of the Moro reflex include the following:

- Primitive reaction to change of position, or balance before higher systems of control have become available
- May assist in taking the first breath of life.
- Activates the fight/flight response
- To alert, arouse and summon assistance

The Moro reflex can be activated by:

1. Sudden change of head or body position (vestibular/postural)
2. Sudden change of light (visual)
3. Sudden loud noise (auditory)
4. Sudden change of temperature or pain (tactile)
5. Smoke (olfactory)

The Moro reflex provides a middle stage in the development of startle reaction patterns. The most primitive startle response can be seen in the withdrawal response, evident as early as 5 to 7½ weeks after conception, when light touch around the oral region of the embryo elicits a withdrawal/freeze response. The withdrawal reaction gradually becomes integrated into the Moro reflex during subsequent uterine development. Whereas the withdrawal response is characterised by shutting down of the system (possibly an early precursor to later functioning of the parasympathetic division of the autonomic nervous system), the Moro reflex stimulates the sympathetic nervous system resulting in arousal, and secretion of adrenaline and cortisol—the hormones most associated with response to stress. Over-stimulation of the stress hormones can result in adrenal fatigue, altered immune functioning (including over-active immune response) and the development of allergies.

2.2 Symptoms

The symptoms associated with a residual Moro reflex include the following:

- Hypersensitivity and over-reactivity to sudden stimuli.
- Vestibular related problems such as motion sickness, which continues beyond puberty.
- Poor balance and coordination.
- Difficulty catching a ball or processing rapidly approaching visual stimuli.
- Immature eye movements and visual perceptual abilities, particularly *stimulus bound effect* (the inability to ignore irrelevant visual information within a given visual field). This can result in difficulty sustaining visual attention and high distractibility.
- Insecurity
- Generalised anxiety and/or fearfulness
- Dislike of sudden unexpected events (e.g., loud noises, bright lights)
- Poor adaptability and dislike of change.
- Adrenal fatigue resulting from easily elicited fight/flight reaction.
- Attention – easily distracted

These are the children who tend to cling to familiarity, dislike change and attempt to manipulate people and situations in order to maintain control over their own reactions. They are often highly intelligent but find it difficult to respond appropriately when a rapid response is required. A discrepancy between verbal, emotional and social behaviour often exists which can cause problems with peer relationships. The Moro driven child can appear withdrawn and fearful in social situations or have a tendency to be overbearing and controlling. They are frequently the children who are "picked on" in the playground because other children recognise their differences and tendency to over react when provoked. The Moro reflex is sometimes seen in adults who suffer from anxiety and panic disorder [11].

Older children with a residual Moro reflex often have a history of allergies and compromised immune functioning. Sometimes it can be difficult to ascertain whether the Moro reflex is the primary cause or is inappropriately retained as a result of disorders in functioning of the biochemical system such as leaky gut, food intolerances and hormonal disturbances. Disorders of biochemistry affect the functioning of the central nervous system and vice-versa.

3. The Tonic Labyrinthine Reflex (TLR)

This is a reflex response to change of head position forwards or backwards through the mid-plane. If a baby is held supported on its back in an adult's hands, and the head is lowered below the level of the spine, the baby's arms and legs extend.

If the head is raised above the level of the spine, the arms and legs flex and the baby curls up into a position similar to the one characteristically adopted in the womb—the position known as 'flexor habitus'.

In the first few weeks of life, the TLR is the baby's only way of responding to gravity. It has not yet developed the neck and head righting reactions necessary to hold its head up, and unless the head is supported, muscle tone will be either predominantly extensor (rigid) or flexed (floppy).

In the first few weeks after birth, the baby makes rapid progress in gaining some degree of control over the TLR. By just 6 weeks of age, it learns to hold its head up in line with the spine if placed on the tummy.

This is a first step towards gaining control over the neck muscles, which will provide the basis for upper trunk control and eventually normal distribution of muscle tone throughout the body irrespective of head position. This mastery of head control is fundamental to later balance, posture and coordination.

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Normal development follows a head to toe (cephalo-caudal) and centre outwards (proximo-distal) sequence. In other words, the first lesson a child must learn is control of the head position on the body. Correct head alignment provides the balance mechanism located deep inside the inner ear, with a reference point from which it can direct other muscle groups and systems such as vision to work together in maintaining balance.

Head control develops first from lying on the tummy, followed a few weeks later when lying on the back. It is important for a baby to have plenty of opportunity for freedom of movement in both positions if it is to gain adequate head control in the horizontal plane. Head control and adjustment will then be challenged as the movement and postural capabilities of the child develop to include, rolling, crawling on the stomach, sitting (semi-upright), creeping on hands and knees and eventually standing and walking (vertical). As later righting and equilibrium reactions replace primitive reflexes, balance becomes more stable; muscle tone improves and reaches into the highest levels of function. "It becomes part and parcel of postural manipulative behaviour, including the adjustments of oculo-motor and laryngeal muscles. Organised tonus is the living framework of voluntary movement and acts of attention [12]."

It takes up to 3-3½ years of age for the TLR to be fully inhibited by higher centres in the brain, indicating just how *many* stages and skills need to be built one upon the other before control of balance and tonus become an automatic (subconscious) function. You only have to watch a baby taking its first steps - wide gait, arms in the air, lurching forward and staggering from one foot to the other – to recognise how precarious man's relationship with gravity is. Initially each step is taken to stop itself from falling over. This is a major discovery; that by putting one foot in front of the other, effective locomotion results; the view of the world is better and once balance is mastered, the hands also become free, opening up all sorts of possibilities for further exploration and development. Inhibition of the TLR, together with development of head righting reflexes, provide the basis for automatic control of balance, tonus and eye movements.

3.1 Functions

Functions of the TLR include the following:

- Primitive reaction to alteration of head position through the mid-plane.
- Facilitates contraction and extension of major muscle groups to develop muscle tone and muscular control.
- Facilitates the beginning of extensor muscle tone (by helping to straighten the baby out from the curled up foetal position adopted inside the womb).
- Interacts with a series of other reflexes and reactions over the course of the first 3½ years of life to provide the basis for head control, balance, postural stability and other dependent functions.

Like the Moro reflex, the TLR has a natural obsolescence. As movement capabilities increase and later reflexes develop, the TLR is gradually modified so that by 3½ years of age, higher systems have gained control and the TLR can be inhibited, only to be called upon if accident, injury or extreme circumstances arise. If for any reason, later reflexes do not develop properly, traces of the TLR can remain active in the older child and have an adverse effect upon balance, motor abilities and stability of eye movements.

3.2 Effects

The effects of a Residual TLR include the following:

- Postural instability arising from head position or movement through the mid-plane, which then has an affect upon –
- Balance
- Muscle tone
- Timing of signals from the body to the balance system and related circuits such as centres involved in the control of eye movements.

3.3 Symptoms

The symptoms of a Retained Tonic Labyrinthine reflex include the following:

- Poor balance
- Postural problems
- Walking on the toes (after the age of 3½)
- Floppy or "tight" muscle tone
- Control of eye movements
- Visual-perceptual problems
- Vertigo
- Motion sickness which continues beyond puberty
- Orientation and auditory confusion.

4. The Asymmetrical Tonic Neck Reflex (ATNR)

The ATNR affects muscle tone differently on each side of the body, in response to turning of the head to either side. The reflex emerges approximately 18 weeks after conception, at about the same time as the expectant mother starts to feel her baby's movements for the first time.

When the baby turns the head to one side, the arms and leg extend in the same direction as the head movement, and the opposite limbs flex. This movement increases in strength during pregnancy, helping to develop movement, particularly turning movements in the confines of the womb as well as muscle tone.

It has been suggested that the ATNR together with other reflexes helps in the birth process. In a normal presentation, between 32 and 34 weeks, the baby turns to position itself with the head facing down towards the mother's pelvis. The presentation of the baby refers to the part of the baby that overlies the entrance to the birth canal at the brim of the pelvis. In this position, the head is bent forwards with the chin resting on the chest, the arms crossed, the legs bent at the knee and the feet crossed over the genitalia. The ideal position for both mother and baby at the onset of labour is for the baby to lie with its back facing to the front of the mother's abdomen in an "anterior" position with the baby well flexed and the head placed over the pelvic brim ready to engage.

As labour proceeds, the baby is not only pushed slowly down the birth canal as a result of maternal contractions alone, but must also perform an 180° turn, moving down the birth canal in a slow spiral. This turn is necessary for the baby to ease its way through the tight dimensions of the mothers' pelvis relative to the baby's own head size. The average pelvic opening in human females is 13 centimetres at its largest diameter and 10

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centimetres at its smallest. The average infant head is 10 centimetres front to back, and the shoulders are 12 centimetres across [13]. The widest part of the birth canal is from side to side, but this changes half way down so that the long axis of the oval extends from the front of the mothers' body to her back. In order for the largest parts of the baby to be aligned with the accommodating parts of the mother, the baby must carry out a sequence of turns. Several reflexes help the baby to do just this; the ATNR by giving flexibility to the shoulders and the hips as pressure is exerted on the neck and the Spinal Galant and Perez reflexes by responding to pressure exerted by the vaginal wall on the lumbar region. The Spinal Galant facilitates movement of one hip while the Perez reflex results in a forward-backward thrust (lordosis) of the lower part of the spine. If the birth was very rapid (precipitate) or the baby became "stuck" in the birth canal and obstetric intervention such as forceps, ventouse extraction or emergency Caesarean Section was required, it is possible that either the ATNR was not strong enough, or the position of the baby prevented it from being utilised effectively. This can have implications for the ATNR later in development.

Normal vaginal delivery is believed to confer many benefits on the baby: While on the one hand, birth is often said to be a dangerous and traumatic journey for the baby, on the other, it helps to prepare the baby to meet the world outside the womb. Maternal contractions provide possibly the deepest massage we will ever experience in our lives, helping to rid the lungs of fluid in preparation for breathing, prime the kidneys for effective urination after birth and awakening the sensors of the skin and proprioceptors located in the muscles, tendons and joints for control of movement in a gravity based environment. Reflexes, which have developed during life in the womb are thought not only to assist in the birth process, but are also strengthened during birth to support survival in the early weeks and months of life before connections to higher centres in the infant brain are established.

Normal delivery is also thought to "prime" the immune system as the baby is exposed to bacteria normally present in the maternal vaginal and anal tracts, which help to confer a natural resistance to exposure to the same or similar bacteria in life.
Various studies have indicated that children born by Caesarean Section have an increase in the incidence of allergies. A study carried out at the Norwegian Institute of Public Health in Oslo in 2005 found that out of 2,656 babies, those born by Caesarean Section were twice as likely to develop an allergy to cow's milk compared to those delivered naturally. None of the children who grew out of intolerance to cow's milk by their second year had been born surgically. The same team had previously discovered a link between Caesarean birth and egg, fish and nut allergy [14].

In the first few weeks of life, the ATNR can readily be seen when the baby turns its head to one side. If the baby is placed on its tummy, the ATNR should come into action so that the head automatically turns to one side thereby ensuring that the airway is free. When asleep on the back, the baby will often adopt an ATNR attitude. Inhibition of the ATNR is a gradual process that undergoes progressive change with increased maturity and acquisition of other abilities related to posture, tone and bilateral integration (use of the two sides of the body together).

At birth, the neonate is very short sighted and can only focus at a distance of some 12 – 17 centimetres from the face – the same visual distance that is used when feeding. The newborn is not aware that its hands are part of itself. Movement that takes place within its limited visual field, such as movement of its own hands, fascinates it. As long as the ATNR is active, head rotation results in extension of the arm with the eyes following the fingers in the same direction. The baby is not yet aware that the moving toys in front of his face (his own hands) are actually a part of himself; they come and go as he moves his head from side to side. In other words, eyes, hand and head are all bound together in a single movement. This movement places the hand in a new position from which it can be viewed at a greater distance helping to extend the baby's focusing distance from near–point to arm's length.

Within a short period of time, the hand will come into contact with solid objects enabling the baby to feel and see how far the object is away from it. In this way, movement, vision and touch operate together to sow the early seeds for accommodation – the ability to focus the eyes at different distances. Early attempts at reaching are also helped by the ATNR. As the ATNR is inhibited (circa 6 months of age), eye and hand movements become increasingly free from head movement. This sequence of events has led a number of authors to observe that the ATNR provides the first hand-eye coordination training in the early weeks and months of life [15].

Inhibition of the ATNR results in less asymmetrical distribution of muscle tone; the baby can start to bring its hands to the midline; eye movements start to operate independently of head movement which results in greater stability of visual image on the retina. This is important in order to be able to visually "fixate" on an object despite movement of the self or the environment.

Although the ATNR is inhibited in its crude form around 6 months of age, it remains present as an "attitudinal" reflex into later life, so that if balance or posture becomes insecure the ATNR will temporarily reappear until balance is restored. This can be seen at various stages of motor development, when the child acquires a new postural ability such as sitting or standing; the ATNR may re-emerge for a short period of time until stability and confidence in the new found skill are established.

Sometimes in adult life, the ATNR is intentionally released from cortical control to assist in the execution of specific skills that involve shifting of balance to one side. Fukuda [16] demonstrated the ATNR being deliberately accessed by a ballerina, a pole-vaulter and an archer, who enrol the ATNR to affect an "attitude". Such examples show that although reflexes become integrated during the course of normal development, they never entirely go away. They can be called upon at any time to enhance performance, or, as a last line of defence when the centre of balance is shifted.

4.1 Functions

Functions of the ATNR include the following:

- Facilitate movement and exercise muscles in the womb
- Assist in the birth process
- Turn the head to one side so that breathing can take place when lying on the tummy (newborn).

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- Develop homolateral (one sided) movements, which help to break up the total body movement patterns seen in the newborn.
- Develop early hand-eye coordination
- Facilitate early reaching movements

4.2 Effects of a Retained ATNR

Sometimes the ATNR fails to be inhibited by higher centres in the brain in the first year of life. In contrast to the ballerina or the pole-vaulter who *choose* to utilise the ATNR in order to carry out a particular movement (voluntary selection), the ATNR *imposes* itself on other movements when the head is turned to one side (involuntary control). This can interfere with the development of balance and coordination in various ways:

- Problems crossing the midline of the body if the head is turned to one side, effecting
  1. development of cross pattern movements
  2. crawling on the stomach
  3. bilateral integration
  4. establishment of laterality (preferred side) by 8 years of age
- Development of independent eye movements (the head and eyes still want to move together). This can then have an effect on visual tracking at a later age Visual tracking is necessary for reading and writing.

Abnormal primitive and postural reflexes in the older child interfere with the *functioning* of higher centres in the brain. These functional problems are unrelated to intelligence but result in impaired performance when carrying out motor dependent tasks such as writing.

A recent study [17] examined the reflex status, balance and coordination of over 600 children in mainstream schools. Assessment revealed that 48% of 5 – 6 year olds and 35% of 7 to 9 years olds still had traces of abnormal reflexes (Asymmetrical Tonic Neck Reflex, Symmetrical Tonic Neck Reflex and Tonic Labyrinthine Reflex). Children in the 5 to 6 year old group were also assessed using educational measures at baseline. Researchers found that children with the highest levels of reflex and balance problems performed less well on educational measures.

Additional studies [18] investigated whether a specific developmental movement programme (The INPP Schools' Programme) carried out in school for 10 minutes a day over the course of one academic year was effective in improving the reflex status of 7–9 year olds. Children who took part in the movement programme showed statistically significant greater improvements on reflex tests, measures of balance and coordination and the "Draw a Person Test" (a measure of non-verbal cognitive performance) than control groups who did not do the programme and comparison groups who carried out exercises of a general nature, for the same time period each day.

5. Summary

Testing of primitive and postural reflexes at key stages in development can be used for several purposes:

1. To identify immaturity in the functioning of the central nervous system
2. To provide indications of the level of development at which remedial intervention should be aimed.
3. As reliable measures of change before and after intervention.

Evaluation of reflexes could be more widely used to identify children who are under-achieving and for whom immaturity in the functioning of the Central Nervous System is a contributory factor in compromised functioning of the immune system (allergies), inattention and behaviour related problems. Studies cited above using the INPP Schools' Programme indicate that in many cases neurological dysfunction can be improved using a specific programme of intervention. As primitive reflexes are integrated into more advanced postural abilities, so the basis for balance, coordination, non-verbal skills and selective attention improve, reducing stress and the demands placed on the body's biochemical reactions to stress.

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