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Each person is an individual and has a unique psychological profile, biochemistry, developmental and social history. As such, advice will not be given over the internet and recommendations and interventions within this website cannot be taken as a substitute for a thorough medical or allied health professional assessment or diagnosis.

Sensory Motor Integration and Learning

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WHAT IS SENSORY INTEGRATION?

The brain is truly the most amazing computer ever devised. It receives countless pieces of information from internal and external stimuli at every second. The ability to classify, organise, store, recall and utilise this information provides the basis for learning. Sensory integration is therefore described as "the organisation of sensation for use" (Ayers, 1995).

Sensory processing is the organization of sensory input from the body and the environment for use. Praxis is the ability to plan and sequence unfamiliar actions. Motor performance is the actual execution of the gross and fine motor coordination.

The brain directs and processes the traffic flow of information and translates it into a language that it can understand, one that is primarily electrochemical.

Through our five primary senses, we learn and develop through interaction with our environment, and through the special senses of proprioception, nocioception and the vestibular system, the brain is able to ascertain the status of the body and make relevant adjustments in relation to its environment. The vestibular system consists of two main parts - three fluid filled semi-circular canals set at right angles to each other in the middle ear, and two vestibular sacs also filled with fluid.[6]

Various receptors used by the nervous system for information gathering are found throughout the body and include:

- proprioception, via proprioceptors, provides information about muscle tension body position and the position and movement of our joints in relation to each other (spatial awareness)

- nocioception, via nocioceptors the sensation of pain due to physical or chemical damage to tissues

- vestibular system, located in the inner ear, provides information about gravity, balance and movement

Sensations may be thought of as "food for the brain", and when they flow in an integrated manner, the brain can use those sensations to form perceptions, behaviours and learning. Without integration, the sensations cannot be 'digested' and used.

Perception involves synthesising and assigning meaning to sensations by taking into account our expectations, our prior experiences and usually, our culture. Perceptual discrimination is based upon the child's sensory modulation and higher order cognitive processes. The primary perceptual functions to be assessed in young children include visual, auditory, and tactile discrimination. Some higher order perceptual skills include visual or auditory figure ground perception, visual-spatial relations, auditory memory, tactile localization, and stereognosis.

Sensation is influenced by the task demands and the child's prior sensory experiences, current state of arousal, and affective state. For example, a light touch perceived as pleasant by one child might be considered threatening or even painful by another.

Behavioral expression of sensory processing must be considered in terms of the child's self-regulation of arousal, attention, affect, and action (Williamson and Anzalone, 1997). The child's sensory status moderates, and is moderated by, the child's state of arousal. Arousal is a child's level of alertness and the ability to maintain and transition between different sleep and waking states.

The state of arousal is usually decreased with a prolonged latency or an inability to attain focussed attention.

MOVEMENT, LEARNING AND THE BRAIN

The human body was designed to move, and it is our early experiences that lay the foundation of what follows.[2]

Every movement is a sensory motor event, and movement reinforces our learning capacity - to truly store something mentally, some type of movement activity is required - either speaking out loud, writing or other physical action such as gesticulation. By putting it into 'muscular memory' it is more likely to be remembered than something simply thought about and not 'acted out'.

The brain develops from the moment of conception and continues to develop - normally in an ordered set of sequences well after birth. For more on the brain, brain function and the human nervous system, please see the following articles:

- Stages of Brain Development
- Post Concussive Syndrome / Head Injury
- The Relationship Between Vital Energy And The Human Brain And Nervous System

Constant sensory input and processing are required throughout life as well as in the early stages to maintain active development of neural networks within the brain. These networks are constantly being structured by dendrite formation and pruning. Every new motor activity performed generates a burst of dendritic formation creating new connections within the brain. If these new connections are not reinforced, they are literally reabsorbed by the cell body. The brain is a judicious budgeter and will not expend more than it has to, only putting energy into what it actively uses.

For example, a 2 year old child has a nasty infection on the upper eyelid, and because of it's location the doctor decides to put a patch over the whole eye for 2 weeks. During that time the synaptic connections from the right eye to the visual cortex will be reabsorbed by the cell body and right field vision will be permanently impaired.[9] Movement of light across the retina is a necessary stimulus for dendritic growth and reinforcement of those connections within the visual cortex.

Of particular interest to us in context of this article is the area of the brain known as the Somatic Sensory Cortex. It operates much the same way as the visual cortex, and corresponds with voluntary control of the various body parts (leg, neck, head, arm, elbow, forearm, hand, fingers, thumb, eye, nose, face, lips, teeth and tongue). If any of these parts are immobilised, the synaptic connections controlling those parts are reabsorbed by the cell body and movement is compromised. Rigorous therapy and retraining to form new neural pathways will become necessary.

The old adage "use it or lose it" is more true than most people think.

Movement actually promotes good health in many ways. Consciously controlled and coordinated movements stimulate production of neutrophins (stimulate nerve growth), increasing the number of connections in the brain.[4] The more precise the movements, the more developed the networks will become.

There are strong links between the motor cortex and the reasoning parts of the frontal lobes. Most of our planning and thinking is object related initially. In planning to fulfil a conscious desire, the brain is occupied with neuronal activity. Movement stimulates increasing diversity of connections, which allows thoughts to spread beyond its original focus - we can 'think outside the square'. Movement then stimulates creativity.

THE SENSORY EXPERIENCE AND MOVEMENT

70% of sensory input for humans is visual, and vision therefore plays a large part in the process of learning. A reflex called the vestibulo-occular reflex coordinates body movement with head and eye movement to provide a stable platform for vision by compensating with subtle muscle movements, or posture. Over 80% of nerve endings to muscles in the body are directly linked via proprioception and the vestibular system with motor nerves running to and from the eyes.[4]

Hearing of course plays an important part as well, and is very dependent upon movement. The ability to orient ourselves to a sound in our environment is critical for our survival. It is one of the first complex senses that we develop in the womb. After birth, at around 6 -9 months of age, the vestibular control of the neck muscles and the auditory system become linked to a neck righting reflex (The Symmetrical Tonic Neck Righting Reflex - STNR) designed to coordinate head movement with sound.[5]

Many things can go wrong with the sense of hearing and balance. For example, continued ear infections during the critical periods of neuronal network formation will disrupt normal development. Without being able to hear properly, (certain frequencies may be 'blocked' due to the infection) we are unable to process and integrate that information. As a result, language, both written and spoken, may be delayed, the sense of balance disrupted or worse. With each ear infection crucial frequencies of sound are not integrated within the critical time frame of development. Developmental delay is proportionate to recovery time.

In the normal course of growth and development, from foetus to infant to adolescent, there are various important stages or milestones that we must progress through in order to experience sensory input for proper processing and integration for future learning. If we miss or skip such milestones, the integration facility of sensory input is 'not quite there', and we will either learn to compensate for such missed steps, finally inhibit them, or may experience learning difficulties. For further information please read article titled:

- Learning Difficulties and the section on Integration Disabilities

For example, babies who are not taught to sit up, generally do so when developmentally ready *after* the 'creeping and crawling' stages of normal development. Those who are left on their backs for long periods of time may not learn to crawl and instead, will often become 'bottom shufflers', or will pull themselves up to stand and walk, thus missing the important sensory motor experiences of creeping and crawling. It is during creeping and crawling that lateralisation or the 'choice' of the dominant side - left or right, will take place. Excessive use of playpens, bouncers and walkers denies the child free explorative movement on the floor, and any surface which hinders movement (such as slippery tiled surfaces etc.) can be a hindrance to normal development. Early walking under 10 months and not preceded by crawling and creeping can herald future problems, especially if the child is already hyperactive.

This hindrance is in the form of retained 'primitive' reflexes, which should have been inhibited at certain important stages of growth and development. For more on the retained reflexes please see the article on:

- Neurodevelopmental Therapy - Inhibition of Primitive Reflexes

The integration of the cerebral cortex, eyes, hearing, the vestibular system and feedback from the core muscles of the body is central to the process of learning as all are important in our ability to maintain attention to the world around us. This is so because of the intimate connections (called projections) between the vestibular and proprioceptive systems, to hearing, vision and a part of the brain known as the Reticular Activating System (RAS). The RAS is an important mechanism in maintaining our levels of arousal. From waking to sleeping, to our ability to maintain attention, the RAS receives and sends messages alerting the brain to pay attention and prepare to take in and consider information received. Without stimulation to the RAS our attention wanders and we tend to fall asleep or have difficulty concentrating.

Children who cannot sit still and concentrate tend to have a problem in their levels of arousal or RAS activation.

94-97% of children with dyslexia and specific learning difficulties display a difficulty in coordinated movement of the eyes indicating a cerebellar/vestibular dysfunction. This leads to reading problems as the eyes will tend to jump rather than track across a page of writing smoothly. Often, so much effort is expended in control of eye movement, that reading comprehension is poor and the child is inordinately tired at the end of a school day. If it is obvious that a child has vision difficulty, the advice of an experienced behavioural optometrist should be sought. By the same token, development of handedness or laterality is also implicated. Depending on the degree of the problem, many children who persistently reverse letters have not achieved dominant laterality and are mistakenly diagnosed as dyslexic if they are deemed bright, and dull, lazy, or learning disabled if they are not. A lot of the time simply correcting handedness by finding the naturally dominant handedness will correct the problem.

It takes 7-8 years of play and movement to provide a child with sensory motor intelligence that can serve as the foundation for intellectual, social, and personal development.[1] Without early intervention, children with sensory integration difficulties seldom "grow out of it".

Correct stimulation of the nervous system at the right stages of development is the key, provided that no underlying organic causative such as heavy metal toxicity, food allergies or genetic factors are present. For more information see article on:

- Food Allergies, Coeliac Disease, Milk Intolerance & Nutritional Issues

A professional knowledgeable about child development from a variety of disciplinary perspectives is capable of conducting a screening assessment. Landmarks of Motor Development

LANDMARKS OF MOTOR DEVELOPMENT

The following table represents a guide to landmarks in motor development.

It should be remembered that every individual is unique, and each will develop according to their own developmental 'programmes' (usually genetically and environmentally based). Children vary greatly in their acquisition of walking, running and speech. If you have any concerns in these areas, please consult your health care professional as delays in seeking advice may have considerable significance to future learning ability. Playing 'catch-up' years down the track is no easy road - for the child or the family. It is always a wise precaution to take your baby regularly to your local Child and Family Health Services Centre or Early Childhood Health Centre - particularly during the early years.

Age	Motor Behaviour	Hand – Eye Coordination
1 Month	• Preference to lying on back	• Looks at object held directly in field of vision. • Grasps reflexively if object is placed in hand. • Eyes begin to coordinate.
2-3 Months	• When lying on stomach, can lift head to 45° and extend legs	• Follows object visually within a limited range. • Looks at object but can only grasp by reflex.
4 Months	• Can roll from back to side • When lying on stomach, can lift head to 90°. Arms and legs are able to extend • Is able to sit propped about for around 10-15 minutes	• Follows objects with eyes through 180°. • May touch or grasp an object when presented with it. • Brings any object grasped to mouth.
5-6 Months	• Rolls from back to stomach • Will often 'bounce' when held in standing position	• Can grasp small block using palmar grasp - there is little use of thumb and forefingers. • Cannot pick up tiny objects, but may scratch at them. • Sometimes holds own bottle with one or two hands.
7-8 Months	• Can lift feet to mouth when lying on back • Able to sit erect for a few minutes	• Able to grasp a small block and may transfer it from hand to hand
9-10 Months	• Creeps on hands and knees • Can sit indefinitely • Able to pull self to standing position and 'cruise' along table etc. • Often able to sit form the standing position	• Pokes at objects with forefinger • Able to play 'pat-a-cake' • May uncover a toy they have seen hidden
11 Months	• Actively pulls self to feet and 'cruises' along table • Will often stand momentarily without support • Able to walk if hand is held and may take a few tentative steps alone	• Begins to use the pincer grasp on smaller objects and uses thumb opposition on larger • May try to stack blocks
12 Months	• Able to get up and walk unaided - may take several steps alone • Creeps up stairs on hands and knees • May be able to squat or stoop without losing balance • Able to throw a ball	• May help to turn the pages of a book • Able to stack blocks • Able to find toys hidden under things • Enjoys putting objects into containers and taking them out again

At this point in the cycle of development, the reptilian brain (that part of the brain considered to be the oldest in terms of evolution) is the focus of refinement. It is a period of motor exploration.

Some points you should pay attention to which may be indicative of developmental problems are:

- The normal newborn adopts the flexion posture and any deviations may be indicative of hypotonia for any number of reasons
- Asymmetry of movements up to 1 month of age may indicate birth injuries, neurological or congenital problems and professional advice should be sought
- Feeding, chewing or sleeping difficulties
  For more information see article on:
  - Sleeping Disorders
- Sluggishness, preferring to just sit and is not interested in investigating the world about him
- Overactivity
- Is exceptionally upset by loud sounds
- Stiffens when handled
- Frequent tantrums
- Uncontrolled crying for long periods
- Doesn't cry when physically hurt
- Persistent head-banging or rocking (It is not abnormal for a young child to rock intermittently while on hands and knees)
- Any other worrying behavioural difficulties

FROM 2-3 YEARS OF AGE

During this period of brain development, the limbic system (that part of the brain governing our understanding of self, our emotions, appetite) undergoes refinement. Children can usually run with relative ease by around the age of two. It is here that the child learns to talk - developing vocabulary from 50-200 words, plan more complex actions, and perform them more effectively. At this time, language functions are becoming localised in either the right or left hemispheres of the brain. Without the integration that occurs in this second year of life, all subsequent development would be difficult. Sensory awareness of the body is developed through the sense of touch, and if the child does not integrate these sensations well may have difficulty in learning to do things, trouble playing with toys, negotiating zippers and the like. Climbing is an important step at this age as it truly takes a well developed sense of balance to climb. During this activity the senses of gravity, of proprioception and visual information are further integrated which is an important step toward development of visual perception. Picture books are enjoyed and the pages turned one at a time. Enjoyment of nursery rhymes and attempts to join in are made. The sense of selfhood is also developed at this time, and the word "no" is often used to express this newfound independence. Although at one moment they will assert their independence and in the next, they want to cling to their care givers to feel reassured that they are safe and secure in the world. The integration of sensations provide the foundations for good relations with other people.[1] By the end of this stage of development they also show signs of empathy, sharing the joys and sorrows of others. Some things to watch for at this age are:

- Tip-toe walking - if this is prolonged you should seek advice.
- Inability to jump with both feet simultaneously without help.
- Any indication your child is not hearing clearly, and signs of difficulty in understanding simple commands.
- Excessive (more than other children of his/her age) fumbling, clumsiness and dropping of things.
- Poor behaviour with other people may indicate an inability to deal with the integration of sensations.
- Inability to control a pencil between the thumb and two fingers.
- Inability to straddle and steer a tricycle pushing with the feet.

FROM 3-7 YEARS OF AGE

This period of the cycle of brain development focuses more on hemispheric elaboration, allowing Gestalt (whole picture concepts) to develop. Cognition, imagery, movement, rhythm, emotions, intuition, speech and integrative thought are established. It is during these years that your child becomes a mature being who can talk and relate to many different people. Higher mental functions develop after this age and that development is reliant upon the successful integration of sensory-motor function. Many reflexes should have been inhibited and/or transformed at this critical stage of development.
For clarification see the article on:

- Neurodevelopmental Therapy - Inhibition of Primitive Reflexes

Playgrounds with swings, slippery dips, merry go rounds, monkey bars, see-saws and sandboxes fulfil the needs of a developing nervous system and sensory integration. Finer motor skills are developed and the use of various tools (scissors, knife, fork and spoon etc.) are refined. Most adults take these simple motor skills for granted, but to the developing child, putting on clothes, or tying shoe laces requires all the sensory information that has been stored in the brain during earlier activities. Girls will display their new motor skills with intricate games like hop-scotch and cat's cradle, boys on the other hand will usually display feats of strength and pursue sporting activities.

Things to be vigilant of at these stages of development are:

- An inability to learn their colours
- An inability to solve puzzles for their level
- Do not recognise their own name when written
- Is slow to respond to spoken instructions
- Slow or unable to learn nursery rhymes
- Does not enjoy listening to stories
- Exhibits poor concentration
- Social or emotional problems
- Sleeping difficulties
- Eating problems
- Toilet training problems and / or continued bedwetting etc.
- Lack of a clearly dominant hand (laterality) and an avoidance of tasks that involve crossing the midline

FROM 8-12 YEARS OF AGE

This period of the cycle of brain development signals logic elaboration. Such things as detail and linear processing, refinement of cognitive processes, and the elements of language, reading and writing skills development, the refinement and development of technique and linear math processing. It is also the period (from around 9-12yrs) in which the corpus collosum (the bundle of fibres interconnecting the left and right hemispheres of the brain) are further developed and myelinated (reinforced by a myelin sheath around the axons of the dendritic connections) to allow whole brain processing. By around the age of eight years, a child's sense of touch and proprioceptive abilities are on their way toward full development. He can tell almost exactly where on his body he is being touched. The sense of gravity and balance is usually well established. The child can balance on one leg and walk a narrow beam. The ability to plan and sequence a number of motor activities should be evident and these will continue to be refined and improved upon in the next few years. Language is usually spoken well enough to communicate ideas, needs and interests.

FROM 12 YEARS OF AGE – ADULT

At 12-16 years of age the developmental emphasis is hormonal, with the individual learning about their bodies, self, and others, community and the concepts of meaningful living through social consciousness.

16-21 years of age sees refinement of cognitive skills, whole mind / body processing, social interaction future planning and investigating new ideas and possibilities

After 21 years of age, elaboration and refinement of the frontal lobes (the site of reasoning) takes place. Global dendritic formation and systems thinking with a high level of formal reasoning are developed, emotional tone is refined - altruism, love and compassion, insight and further refinement of motor skills is effected. There is usually a growth spurt of dendritic formation and neural net development in the frontal lobes. It is the time when people realise their parents are smarter than they thought, as emotional refinement allows for insight leading to altruism and love.

At 30 there is another growth spurt. This time involving further refinement of muscle movement - particularly of the hands and face.

Learning is a progressive, constantly changing process that serves to enrich and expand our understanding throughout life.

It should be noted that there are many factors which may impede or limit frontal lobe development in the life span. These can include a lack of sensory stimulation, lack of movement, lack of touch (diminished Nerve Growth Factor), unbalanced or incomplete RAS activation, exposure to Electromagnetic Fields (EMFs).

Inadequate water consumption, TV, computers and video games (desensitisation to violence, decreased imaginative development, less interactive communication, ocular lock). Nutritional factors can include such things as: inadequate amounts of proteins, lack of essential amino acids and fatty acids, high carbohydrate and sugar diets; Rigid educational systems can be at fault too - developmentally inappropriate curricula, unawareness of or inattention to unique learning styles.

CONCLUSION

Sensory integration and motor development are intertwined and lay the foundations for the capacity for learning. When problems exist, early intervention is best as habit tracks become harder to shift with age. By careful observation of your child at play, rest and at school much can be gleaned about their neurodevelopmental progress. Through vigilance, persistence, and early intervention by trained and experienced professionals, it is possible to restore balance and guide the child back toward the normal developmental sequence thus providing them with the foundations necessary for learning to enable them to achieve their optimum potentials

FURTHER READING SUGGESTIONS

- Stages of Brain Development
- Post Concussive Syndrome / Head Injury
- The Relationship Between Vital Energy And The Human Brain And Nervous System
- Learning Difficulties
- Neurodevelopmental Therapy - Inhibition of Primitive Reflexes
- Food Allergies, Coeliac Disease, Milk Intolerance & Nutritional Issues
- Sleeping Disorders
- Eating Disorders
- Nocturnal Enuresis or Bed Wetting
- Electro Magnetic Fields and Your Health
- Bodywork, Breathing and Movement for Sensory Integration, General Health and Wellbeing

For more information or to make an appointment please contact us on (02) 9637 9998 during business hours.

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