Neurofunctional Reorganisation according to Padovan and Psychomotor Performance Therapy in children with Down Syndrome

Professional assignment of

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1. Introduction

The purpose of this project is to raise awareness of the Neurofunctional reorganization according to Padovan and to prepare for a long term study with patients diagnosed with Down syndrome. We want the paper to be informative and give the background information needed for such a study by collecting this information from different sources. In an attempt to reveal pitfalls, problems and many other aspects that need to be considered in such a study we will execute a pilot study designed as a long term study.

We will explain aspects about the development of a child with Down Syndrome, focusing on what we believe is important in regard to the therapies, the pathology and/or generally in regard to the development of a child. This part is rather extensive and a reader already familiar to this topic and its influences on motor and language development is benefited by proceeding directly to the next section. The therapies will be introduced in the second section to the reader with background information and the philosophy behind them. The practical application will merely be tangibly touched. The third section holds the information of our pilot study.

We came in contact with the therapy through our client Mrs. Rodenacker. She is a physical therapist and attended the first Padovan course in 1989. She was immediately struck by the concept which Mrs. Beatriz Padovan presented. Nowadays Mrs. Rodenacker uses the Neurofunctional Reorganization according to Padovan in her clinic on a daily basis. We have attended two courses given by Mrs. Padovan and her daughter Dr. Sonia Padovan and our interest was raised as well. When given the opportunity to research and learn in depth about a topic in the professional assignment during our studies of Physiotherapy at the Hogeschool van Amsterdam the choice to us was natural. We wanted to learn about this therapy.

Mrs. Rodenacker offered us to execute a study at her clinic in Cologne, Germany. It was early clear to us that an interesting patient group to look at would be children diagnosed with Down syndrome. The conventional therapy for children with Down syndrome is Psychomotor Progressive Therapy (PPT). It is also being used in Mrs. Rodenacker’s clinic. The inclusion of PPT is therefore logical and necessary in order to make a step towards a conduction of a long term study.
First section

2. Down Syndrome (DS)

In 1866 Mr. J. Langdon H. Down published an article in which he described the nowadays so called Down Syndrome to which he referred to as Mongolism. In his description he regarded the Down Syndrome as a ethnicity and not a pathology. Since Mr. Downs explanations for the development of the syndrome are not reasonable and are founded on a racist theory the term “Mongolism” is being replaced by the term Down syndrome, as we all know it today. Further, we know very well that the syndrome has to do with a genetic problem whereas the cause of this genetic defect is still unknown.

In 1959 a group of French scientists confirmed what had been assumed long before. People with Down Syndrome have a chromosomal anomaly. Each human cell has 23 pairs of chromosomes, meaning 46 in total. Chromosomes are categorized in size and as some chromosomes are evenly big they are further subdivided into groups from A-G. In people with Down Syndrome the 21st Chromosome is for some reason three times present. In 96% (J. Wendeler) of the cases the genetic defect occurs during cell-division (Mitosis). All human cells basically originate from one primary cell (Zygote). This cell splits in two as do the chromosomes within and as these chromosomes split problems may occur. In the case of the Down Syndrome the problem is that the two 21st chromosomes do not split properly (non disjunction) and one of the consecutive two cells has one and the other three of those chromosomes. The earlier this defect occurs during Mitosis the severer will be the manifestation of the symptoms.

If the defect occurs with the very first cell division the result will be that the cell with one chromosome (monosomy) will die and the other will continue to replicate itself. This means that all cells in the human body will have the chromosome three times. On the other hand if the defect occurs at a later stage only some of the cells will have three 21st chromosomes. This has been termed Mosaic-Type DS.

Before the body cells divide, the Keimzellen divides in a complex procedure called Meiose. During this division the cells pairs of chromosomes becomes single strings and when they duplicate the same problem as described before can occur and can possibly have the same result.

In approximately 4% of the cases a so called Translocation can be the cause of DS. Here the chromosome 21 breaks within a cell which will later become a Keimzelle.

The number of children born with Down Syndrome rises steadily, the incidence of Down Syndrome is between 1/800 to 1/1000 births. Scientists contribute this fact of increasing number Down syndrome births to the increasing maternal age. In the maternal age group 20-24 the incidence is 1/1490, at maternal age 40 it is 1/60 and at 49 it is 1/11, still 80% of the children born with Downs Syndrome mothers are under 35 years old. The paternal age seems to be of no influence. Obviously this has also the result that more and more children with Down Syndrome are being aborted since the detection of an genetic anomaly has become a standardized procedure in many western countries.
The influence of extra genetic material on the general health is highly variable and may affect any organ system or bodily process. It is not possible to predict the health problems in the individual during the pregnancy. One of the most common health problems is congenital heart disease with an incidence of around 40-50% it is the most important factor deciding survival in early life, other factors being infections due to impaired immune response and airway obstruction due to anatomical anomalies. 75% of trisomy 21 die in embryonic or fetal stages and 85% of born infants survive until 1 year and 50% can be expected to live longer than 50 years. There is an increased risk of a disorder of the thyroid, the most common one being hypothyroidism being present in 15-20% of the patient population. Decreased fertility and higher incidence of miscarriages, premature births and labor difficulties are present in women while the men are almost uniformly infertile. Women with Down Syndrome are able to give birth to individuals not having the extra chromosome 21. Individuals with Down syndrome are 12 times more likely to develop immunodeficiency then normal. 1/150 individuals develop leukemia, in the first five years the risk of developing acute leukemia is 56 times greater then in non-DS individuals. However the risk of developing other malignancies is greatly reduced. 12% of the DS population suffers from a disorder of the gastrointestinal system with Hirschsprung disease being one of the most common ones causing severe constipation through loss of nerve control of the colon. Growth is affected and individuals generally have a short stature and are in the risk of developing obesity. Neurological aspects are commonly hypotonia and mental retardation affecting development of sitting, walking, speaking etc. Half of the population older then 50 develops Alzheimer’s disease and epilepsy or other seizures are present in 10%. The eyes are often affected with refractive errors being present in 50%, strabismus in 40% and nystagmus in 20% of the individuals. Hearing loss affects more then half of the population. Instability of the atlanto-axial joint is present in around 15% of the cases due to laxity of the transverse ligaments usually holding the odontoid close to the arch of the atlas, can lead to signs of spinal compression. The above mentioned health problems are the most common ones but there are many more possible disorders that can affect the individual. Since the syndrome can manifest itself in as many ways as it does each individual needs an individual approach.

3. Motor Control – an introduction

Motor control, relevant aspects related to motor control and the development of the motor system are subject of this introduction.

Movement emerges from three interacting factors: The individual, the task and the environment (Shumway-Cook 2001). Consequently there are three points of analysis which can be used to look at a movement performance. In the case of this project the individual will be of importance only, as this project is not going to analyze specific movements but only the abilities but also deficits of one specific patient group, children with Down Syndrome (DS). Nevertheless this study will certainly also refer to the normal development of a child which is very similar to that of our patient group.

The three interacting factors that influence the generation of movements within the individual are: Perception, action and cognition.
Perception is defined as the integration of sensory impressions into psychologically meaningful information (Shumway-Cook, 2001). Perception/Sensory systems give information about the environment and objects in the environment but also the human body in space.

The action system or “output” system does not merely involve our muscles or the lowest level of the central nervous system (CNS) but all those brain structures generate and refine movement, them to become coordinated.

Cognition is broadly defined and includes motivation, attention memory. Cognition is an important factor in motor control as almost all movements are done with an intention or goal for which cognitive processes are necessary. Shumway-cook also include emotions as an influentiaal aspect which is shown in the later part about the Psychomotor Performance Therapy. The motivation to move is important, especially in the first years. Then this motivation is referred to as Mastery Motivation. Memory is important for the automatization of movement patterns. Only after an automatization of one movement more complex movements can be learned on top of the previous one. It is not completely clear how and where cognitive processes influence motor actions.

The integrity of these systems is the fundament of a well functioning and efficient motor system.

3.1. Perception systems (“input systems”; “feedback/feedforward systems”)
Movement arises from the interaction of perception with the action system, whereby cognition influences both systems at various levels. The CNS is not governed by a purely hierarchal order but rather there are roads on which the information is passed on up- or downwards but at the same time sideways or parallel. The interaction between the previously mentioned systems is what is to be kept in mind when going through the further sections.

The lowest level of the perception/sensory system is the receptor. Wither it concerns the visual, the audio or the vestibular system, all sensory stimuli are detected by receptors.

The human body has receptors in its muscles, tendons, skin and in and around the various joints. In the muscles (muscle spindle) and around the tendon (Golgi Tendon Organ) they respond either to passive stretch or to contractions and give proprioceptive information about the location and position of the different body parts in space and tonus of muscles.

The cutaneous receptors (skin receptors) give a lot of different information to the CNS. They respond to different kinds of stimuli such as pressure, vibration, temperature and noxious stimuli. The most important information given in regard to the motor system of these receptors are reflex-responses at lower levels and the detection of information about the immediate environment of the individual at higher levels. Certainly there are many other essential tasks that this system fulfills but which are not of high relevance in concern to the motor system.
In our joints and around our joints various receptors which are fairly similar to those around the tendons or others in the skin have a similar duty. Primarily they give information about the position of our limbs or body in space like the receptors in the muscles. Nevertheless, **proprioception** is the main duty of this system.

Proprioception is fundamental to movement and one important part of our feedback system which refines movements. A. Jean Ayres (occupational therapist and publisher of pioneer works in the area of sensory integration, 1984) emphasizes that if we would not have proprioception, all our movements would be slower, clumsier and would cost us fare more energy because we would lack essential feedback information. Most of these proprioceptive sensations do not reach the somatosensory cortex and do not become conscious to us, still it is of fundamental importance for motor control.

**Vision** gives us a lot of information which can either help us to identify objects and tell us about the movement of that particular object (exteroceptive sense) or it gives us information about our own body parts in space, their in relation to each other and about their direction of movement (visual proprioception).

The **vestibular system** is sensitive to two kinds of information: position of the head in space and sudden change in direction of movements of the head. It stabilizes the eyes and helps to maintain postural stability during walking. Some specific receptors (Utricle and Saccule) also provide information about the body’s position with reference to the gravitational force and the linear acceleration or movement of the head. The perceived stimuli from these receptors travel to various parts of the CNS. It is one of the first feedback systems that functions.

Before the information from the receptors reaches cortical and subcortical areas in the CNS it passes through the **brain stem** and the formation reticularis. The brain stem marks one of the oldest areas of the brain. Only what is at this point adequately recognized can be used by higher processing areas. It comprises the processing of vital functions such as breathing, sucking and swallowing but also postural functions such as primitive postural reflexes (“halte- and stellreflex”).

The **formation reticularis** which is part of the brain stem, receives input from all sensory areas and plays a special role in the processing of tactile, proprioceptive (kinesthetic) and vestibular stimuli. It presents a control mechanism of incoming sensory information and integrates the stimuli from the different senses as a preparation for further processing at a higher level. Through inhibition or the intensification of stimuli it accentuates certain stimuli and directs the attention of higher centers towards certain stimuli. It has often been referred to as the alerter of the CNS.

The **Thalamus** is a structure located in the central area of the brain. It receives information from higher centers of the brain and is considered one of the major sensory processing centers. From there the information finally reaches the somatosensory cortex where the information becomes conscious to us and you can see the first cross modality processing happening. Input from all receptors of one body area is being integrated and put into association. It becomes conscious to us. The body is being mapped on the cortex.
according to the importance of the sensory information coming from the different areas of the body. On the other hand, the cortex has also descending tracts going to the thalamus, dorsal column nucleus and the spinal cord and therefore it is able to modulate ascending information to these centers.

The next step is to find a connection between perception and action. This can be found in the association cortices (Shumway-cook, 2001). Here too the interplay between higher level cognitive processing and higher level sensory processing become apparent. There have been a couple hypotheses about the various tasks of the different areas of these association cortices. Through research a lot has been discovered and the reader is referred to Shumway for detailed a descriptions.

3.2. Action systems

There are certain brain structures that are of specific interest in the process of a motor action. This section will comprise all those brain areas that take part in a coordinated motor action with the exclusion of cognitive procedures which will be the topic of the following section. The tasks, differences and connections between the motor cortex, the basal ganglia, the cerebellum are going to be discussed. This marks the pathway from the higher centers towards the periphery and the execution of movements.

The motor cortex is the area of the brain that is most active when movements are carried out and it consists of three processing areas: the primary motor cortex (MI), the supplementary motor area (MII) and the premotor area. These areas interact with sensory processing areas and the basal ganglia and cerebellar areas to identify where we want to move, to plan the movement and to finally execute our action (Shumway-cook, 2001).

All three areas have their somatotopic maps of the body. Stimulation of one neuron in the primary motor cortex results in a response of a specific α-motor neuron whereas in the other two systems the stimulation of one neuron results in an activation of multiple muscles, at multiple joints which gives rise to a coordinated movement.

Input to the MI comes from the basal ganglia, the cerebellum, and sensory areas including information directly from the periphery via the thalamus (before it becomes conscious to us).

Outputs reach the effector cells via the corticospinal tract (50% primary motor area, rest other motor areas and even somatosensory output).

A scientist named Evarts (shumway-cook, 2001) found out that both, the absolute force and the speed of a movement are controlled by the primary motor cortex. Force and speed are in particular important for the coordination of movements and with it for the tonus regulation. Other researchers who continued his path came to the conclusion that a movement is controlled by a population of neurons instead of one α-motor neuron. This implicates that
there are multiple pathways to come to a specific movement. This is as well interesting for different therapy approaches.

The **supplementary and premotor** areas are involved in a number of processes. Primarily they are responsible for more complex movement tasks in contrast to the primary motor cortex but moreover they are involved in forming sequential, but simple ballistic motor plans (Shumway-Cook, 2001).

The same researchers suggest that the supplementary motor area is specialized for controlling internally referenced motor output and the premotor area being specialized with externally referenced motor acts. Studies support this theory by showing that lesions in the premotor area will hinder the recovery in accordance with visual cues and lesions in the supplementary motor area will impair recovery of self-initiated movements. It becomes apparent that there are small but essential differences between these three areas and further research is necessary to come to more precise and definite conclusions.

In the frontal region higher level association areas are located and it has been hypothesized that these areas integrate sensory information and then select the appropriate motor response from the many possible responses (shumway-cook, 2001).

The **cerebellum** is involved in a number of tasks. It is thought to be responsible for the coordination of movements in a conjunction with the basal ganglia and the cerebral cortex. It is further involved in the process of the memorization of movement patterns, the required fine tuning of the muscle groups. Since it stands in close relation to the brain stem, it is also involved in the connection between postural control and movement patterns and the maintenance of balance. Generally, the cerebellum acts as a comparator which means it compares the intended movement with the actual performance afterwards. Its output goes back to the motor cortex and other systems in the brain stem where it is being modulated before it is transferred towards the periphery.

The **basal ganglia** are the last structures to be included in this introduction. It has many similarities to the cerebellum in its functions but also differences; still they should be seen in close connection to each other. First the basal ganglia are the termination site for tracts from the entire cerebral cortex but not the spinal cord (Alexander and Crutcher 1990). Therefore they are not influenced by direct feedback from the periphery but depend more on the information coming from higher centers. Due to their different projections it has been hypothesized that the basal ganglia may be predominantly involved in self-triggered movements and the cerebellum rather in visually guided movements (Shumway-cook, 2001). Other researches suggest that it is also involved in activating certain movement patterns while inhibiting others (Alexander and Crutcher, 1990). This might have an influence on the response selection to a sensory stimulus or an intention. Most probably the basal ganglia are involved in all of these processes but further research needs to be conducted to state any definite conclusion about its definite tasks.
3.3. Cognition
This section is not going to be about real systems because a number of brain areas and systems (such as the limbic system, the thalamus and the cortex) are involved in the processing of cognitive and emotional functions. This section is rather going to explain how cognitive processing can influence motor control. Attention, memory and motivation are going to be discussed.

3.3.1. Attention
There are different types of Attention and for example, focused attention is important for the acquisition of new motor skills. On the other hand divided attention can be important in order to carry out one motor task at a subconscious level and pay attention to other stimuli at the same time. These are only two examples but all sorts of attention (focused, sustained, divided, etc.) can be important for motor performances.

3.3.2. Memory
Memory is the ability to process, store and retrieve information. In this case it is significant as motor programs are also stored and need to be retrieved in an attempt for certain intentions or responses to a stimulus. Memorized motor programs put less demand on the processing centers of the brain and can therefore be carried out in a quicker, more efficient and accurate manner. It saves energy as it is usually performed at a subconscious level and creates space for other cognitive processing or new motor tasks.

3.3.3. Motivation
Motivation refers to the initiation, direction, intensity and persistence of behavior (Geen, 1995). Children have what is so called mastery motivation which means the intrinsic motivation to interact with the environment. This mastery motivation can be seen as an engine of a child which pushes the development and is therefore of particular importance.

Overall it becomes clear that cognition which influences the motor system at various levels during a motor performance has also a reciprocal relationship to the motor system. Although it influences the motor system the development of cognitive, social and behavioral abilities is extremely hindered if motor skills (basic but also fine motor skills – especially speech) are not sufficiently developed.

3.4. Feedback loop of perception
The feedback or input systems give us information about our surroundings and our self. This information is used by higher centers to construct a movement program or plan which suits the environmental restrictions but is still aiming at fulfilling an initial goal. First we picture the movement in our head and then we perform the intended movement. During (feedforward) and after (feedback) the movement we compare the performed movement with the intended movement and with each repetition we refine our movement program which we are creating when practicing for example specific sports. All of the
above mentioned systems are necessary to perform a coordinated movement and to automatize this movement in order for it to reach a subconscious level and to be able to direct your attention elsewhere.

The scheme below shows the interplay between the perception and the action system. Cognition is disregarded and it is in general strongly simplified for didactical reasons. The scheme displays how movement planning and execution is being influenced by perception.

(BG = Basal ganglia; CX = cortex; CB = Cerebellum; RF = Reticular formation; BS = Brainstem; SC = Spinal cord)

Explanation of the scheme above: The cortex generates an intention which requires a movement. This intention or movement sequence is encoded in biochemical signals which are sent to the control system (BG, the CB and the RF) where the plan is being examined. At the same time the body also receives direct input from the above mentioned systems (vestibular, visual and auditory system). The examined information from the control system and the direct input information is summed and then passed on to the effector cells or motorneurons (located in the BS and SC) which innervate the muscles to carry out the movement. Source: Annunciato, 1996
4. Motor development
This following section is to give an introduction on the milestones in the motor development, the sensorimotor development and the emergence and dissolution of reflexes.

4.1. Milestones in motor development
The milestones of the motor development are estimated years of age in which a child is supposed to be able to perform certain fundamental motor skills. These estimations have to be acknowledged as estimations only and cannot be taken as golden rules for when a child must have acquired a specific motor skill.

These early milestones are necessities for the development of later motor skills. Head control, trunk stability and walking are basics for further motor control. This implicates that subsequent more complex performance such as writing, sowing or any kind of sports performances require the development of those basic skills.

Gallahue (D. Lane & B. Stratford, 1988) defines the necessary basic motor skills as (1) trunk stability (in sitting or standing), locomotion skills, in order to move within the environment and at last the abilities of reaching, grasping and releasing in order to be able to interact in a meaningful way with the environment.

The table below is a copy from a previous article published by HvA students which used milestones by authors who also analyzed the milestones of healthy children and children with DS. This table shows the milestones of healthy children and in the following section a table will show those of children with DS. They are all from the same authors to make a nice comparison possible.

<table>
<thead>
<tr>
<th>Motor-milestones</th>
<th>Cunningham*</th>
<th>Stray-Gunderen**</th>
<th>Connolly*</th>
<th>Van Empelen*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head raise in prone</td>
<td>3 m (1-4)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Roll over</td>
<td>5 m (2-10)</td>
<td>5 m (2-6)</td>
<td>5 m</td>
<td>5 m (2-10)</td>
</tr>
<tr>
<td>Sitting without support</td>
<td>7 m (5-9)</td>
<td>10 m (9-11)</td>
<td>8 m</td>
<td>7 m (5-9)</td>
</tr>
<tr>
<td>Pull into standing</td>
<td>8 m (7-12)</td>
<td>12 m (9-19)</td>
<td>10 m</td>
<td>8 m (7-12)</td>
</tr>
<tr>
<td>Creep</td>
<td>-</td>
<td>8 m (7-12)</td>
<td>8 m</td>
<td>-</td>
</tr>
<tr>
<td>Crawl</td>
<td>-</td>
<td>8 m (7-12)</td>
<td>10 m</td>
<td>-</td>
</tr>
<tr>
<td>Walks with support</td>
<td>10 m (7-12)</td>
<td>10 m (9-12)</td>
<td>13 m</td>
<td>10 m (7-12)</td>
</tr>
<tr>
<td>Stand without support</td>
<td>11 m(9-16)</td>
<td>-</td>
<td>14 m</td>
<td>11 m (9-16)</td>
</tr>
<tr>
<td>Walks without support</td>
<td>12 m (9-17)</td>
<td>12 m (10-17)</td>
<td>15 m</td>
<td>12 m (9-17)</td>
</tr>
</tbody>
</table>

* = average when children reached the milestone
** = age when 50% of the children reached the milestone
m = months
() = variance
Source: Roos, 2002
4.2. Reflexes

A reflex is an involuntary muscular response to a sensory stimulus. The literature differentiates between classic and primitive reflexes. The classic reflexes are present throughout life (Achilles-Tendon-reflex, Patellar Tendon Reflex) and they are initiated in this case by the Golgi-Tendon-Organ and the muscle spindle. Primitive reflexes (grasp-reflex, palmar- and plantar-reflex or moro-reflex etc.) persist until the infants’ brain is developed enough to inhibit these reflexes (D. Lane & B. Stratford 1988). In the development of an infants’ brain several stages have been recognized. In the first two months the CNS is primarily governed by a spinal level with the increasing age the level of control succeeds to higher levels from the brainstem to the midbrain and finally to the cortical level which marks the point when these primitive reflexes are finally inhibited and under voluntary control. The last primitive reflexes usually subside at an age between 9 and 12 months. Reflexes are the basis for any further motor development. If they persist or if their stimulation evokes irregular reactions, the necessary level of control has not been reached and the further development may be disturbed.

4.3. Sensorimotor development

Jean Piaget a Swiss psychologist described thoroughly the cognitive development of a child. He proposed 5 developmental stages between the ages of 0 to 12 years. The first stage was named “sensorimotor intelligence” and lasts app. 1, 6-2 years. He defines this stage as the stage in which the child is able to “acquire, store and use information about the social and nonsocial environment.” Within this first stage there are 6 subdivisions in which certain basic motor abilities are practiced and consolidated.

1. Stage: The primitive reflexes are being practiced and consolidated.

2. Stage: First associations are made between actions that have positive results (formation of schemes) and the acquisition of information about objects within the environment increases.

3. Stage: Actions and reactions (schemes) are being consolidated. The child forms pictures about the effect of his actions but does not consolidate them yet. The stage is marked by the differentiation of the aim and means. It repeats actions and learns that certain means fulfill the aim.

4. Stage: The child knows how to handle certain objects and knows what certain objects can do. It experiments in different situations and under different conditions with objects and tries to refine its schemes by adopting the correct handling and purpose of these objects to the appropriate conditions.

5. Stage: It further experiments with objects in order to develop further action-schemes by active interaction with the objects. The child tries to find other ways to the same goal than those it has already established.
6. Stage: Actions do not have to be performed to know the result. The child can anticipate the results of its actions because certain schemes have been internalized.

You can see that within the stages the child not only acquires and stores information about its environment but it also gives an appropriate response to external stimuli.

Another pioneer who dealt with the sensorimotor development was the above mentioned A. Jean Ayres. She emphasized the integration of the different sensory stimuli. In order to create an appropriate and meaningful response to a stimulus the different sensory inputs need to be integrated and put into one common context first. Once the senses are integrated and create one common “picture” the motor system can give a response that suits the stimulus.

For her the process of sensory integration is completed approximately at the age of 7. In these years the child is mainly controlled by sensory information. The reactions of the child are not yet connect to cognitive or social rules but are predominantly governed by sensory information. “The child does not think about objects thoroughly but tries to feel them and tries to let its body respond to those perceptions.” Later responses which are controlled by cognitive and social aspects are only to be understood clearly if the previous integration of the senses has been mastered.

Jean Piaget and A. Jean Ayres emphasize the importance of the association between a sensory stimulus and an appropriate action. A. Jean Ayres describes these reactions as an “adaptive response” to a sensory stimulus. An adaptive response is a self-motivated and purposeful action to an environmental demand. Sensory input has been described by A. Jean Ayres as nutrition for the brain which nourishes it and promotes its development. An adaptive response is an indicator and a promoter of sensory integration. Indicator because the quality if the response is dependent on the sensory feedback and a promoter because the movement of the limbs sends well-organized sensory information to the brain (Smith Roley, Susanne; Imperatore Blanche, Erna; C.Schaaf, Rosaenn, 2001).

The sensorimotor development in general is far from over at the age of two, as it has been proposed by Jean Piaget. It continues with every motor task that is being practiced. The difference is that from the age of 1, 6/2 years a child is able to imagine and anticipate the motor actions mentally before it carries them out. Generally spoken the child develops symbolic and imaginative abilities.

5. Motor development in an individual with DS

5.1. Milestones in motor development in individuals with DS
In general, the acquisition of the different milestones is always delayed. Although delayed, the variance (subsequently also the Standard Deviation [SD]) is much bigger in
DS individuals than their normal peers. This goes along with other findings about IQ and DQ (developmental quotient) measurements (J. Wendeler, 1988, D. Cicchetti & M. Beeghly, 1990). These researchers came to the general conclusion that children with DS do not develop differently but only delayed.

<table>
<thead>
<tr>
<th>Motor-milestones</th>
<th>Cunningham*</th>
<th>Stray-Gunderen**</th>
<th>Connolly*</th>
<th>Van Empelen*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head raise in prone</td>
<td>5 m (3-9)</td>
<td>-</td>
<td>3,5 m</td>
<td>-</td>
</tr>
<tr>
<td>Roll over</td>
<td>8 m (4-12)</td>
<td>5 m (2-24)</td>
<td>5,7 m</td>
<td>8 m (4-12)</td>
</tr>
<tr>
<td>Sitting without support</td>
<td>9 m (6-16)</td>
<td>9 m (5-31)</td>
<td>11,3 m</td>
<td>9 m (6-16)</td>
</tr>
<tr>
<td>Pull into standing</td>
<td>15 m (8-26)</td>
<td>16 m (6-47)</td>
<td>18,4 m</td>
<td>15 m (8-26)</td>
</tr>
<tr>
<td>Creep</td>
<td>-</td>
<td>11 m (6-42)</td>
<td>12,5 m</td>
<td>-</td>
</tr>
<tr>
<td>Crawl</td>
<td>-</td>
<td>17 m (6-42)</td>
<td>17,3 m</td>
<td>-</td>
</tr>
<tr>
<td>Walks with support</td>
<td>16 m (6-30)</td>
<td>11 m (9-55)</td>
<td>22,3 m</td>
<td>16 m (6-30)</td>
</tr>
<tr>
<td>Stand without support</td>
<td>18 m (12-38)</td>
<td>-</td>
<td>21,5 m</td>
<td>18 m (12-38)</td>
</tr>
<tr>
<td>Walks without support</td>
<td>23 m (13-48)</td>
<td>24 m (14-64)</td>
<td>24,8 m</td>
<td>19 m (13-48)</td>
</tr>
</tbody>
</table>

* = average when children reached the milestone
** = age when 50% of the children reached the milestone
m = months
() = variance

Source: Roos, 2002

5.2. Sensorimotor development in individuals with DS

The stages determined by Jean Piaget have been recognized in the development of children with DS as well. Several studies have researched the difference in this specific matter of development. The questions of interest were:

- How does sensorimotor development proceed in children with DS (same as or different from the norm)?
- How do children with DS transit from one level to the other?
- And how does the structure differ within one specific stage in children with DS and without?

It has been well established that better sensorimotor performances are to be expected at a higher age level. This also accounts for children with DS whereas in this case there is a higher correlation between mental age (MA) and the sensorimotor developmental level than chronological age (CA) (D. Cicchetti & M. Beeghly 1990). This stands in accordance with the findings about the general development (D. Cicchetti & M. Beeghly 1990; J. Wendeler, 1988). The MA is almost always a better point of reference in relation to the developmental level in individuals with DS.
Dunst (D. Cicchetti & M. Beeghly 1990) gathered data which indicated that children with or without DS “show very similar patterns of behavior interpatterning for between stage transition”. Differences were found in the stage stabilization though. Even when the slower pace of development was taken into consideration, children with DS displayed a larger percentage of regression in development and it took them much longer to progress from one stage to the other in comparison to healthy children. The structure within one level of development seems different between infants with DS and those without. Still, Dunst believes that this issue needs to be researched more thoroughly as the collection of studies which were taken into consideration, did not form a consent outcome. This may have to do with methodological differences of the studies.

These answers indicate to a similar picture than that of the general development of a child with DS. The development is delayed, the regression in development increases slowly but steadily and the stage transition is of particular difficulty.

**5.3. Emergence and dissolution of reflexes and hypotonicity in individuals with DS**

The following part the paper is going to look at some of the early symptoms may influence the later development.

The first symptoms associated and noticed after birth in individuals with DS are marked hypotonicity and delayed emergence and dissolution of reflexes. These two symptoms are not to be separated completely from each other as they stand in close relation.

Many studies have shown that hypotonicity is a marked symptom at least at birth and it may influence the acquisition of early motor abilities. Cowie (D. Lane & B. Stratford, 1988) also noted that with age and increasing muscular activity the hypotonicity decreases to some extent. Many researchers acknowledge this fact but emphasize that it does not subside completely in many cases. What has not been studied thoroughly is if motor performances are affected by a low muscle tone in older individuals with the DS.

In the study of Cowie the early reflexes such as the Moro, the grasp, the palmar and plantar reflexes have been tested and compared to those of normal peers. All reflexes assessed were found to be abnormal in some way or the other. She concluded that hypotonicity was related to the impaired reflexes and that “the pattern of relationships between variables became progressively more definite and clear cut as time went on.”(D. Lane & B. Stratford, 1988). How exactly these reflexes influence the later motor skills has not been studied thoroughly.

Although descriptive research has noted abnormal movement patterns in DS, it is difficult to make a direct connection. Hypotonicity associated joint laxity and abnormal movement patterns could be brought into a connection by the following hypothesis when looking at for example the frequently observed split when a child tries to get into sitting position from prone.

As a child has the thrive to get into sitting position and battle gravity, it knows its body fairly well and knows (unconsciously of course) about the joint laxity which again stands
in close contact with the hypotonicity. Therefore it seems logic that a child in this situation searches for the quickest and most linear way to get into the upright sitting position which is a straight forward movement and ends in a split and then in the sitting position.

The hypotonicity is thought to be of central origin but the precise underlying mechanism which causes the abnormal tone is not yet understood (D. Lane & B. Stratford, 1988). Morris et al. (D. Lane & B. Stratford, 1988) reported that there is a correlation between the degree of hypotonia and the level of strength. Other studies suggest that children with DS have less strength than their mental age matched peers and as a consequence they suggests that people with DS might need more practice to increase strength (B. Sacks & S. Buckley, 2003). Therefore, a later emergence of the achievement of motor milestones has probably also anatomical anomalies as its origin. The shorter arms, in a connection with the hypotonicity and the decreased strength make the battle against gravity in particular difficult.

6. Problems in motor performance in individuals with DS

Ben Sacks and Sue Buckley summarized most of the motor performance problems, people with DS may exhibit. The words “may exhibit” are very important to note as it is generally agreed (D. Lane & B. Stratford, 1988; J. Wendeler, 1988; D. Cicchetti & M. Beeghly, 1990; B. Sacks & S. Buckley, 2003) that there is a greater variability in all domains of the development or performance ability in DS than usual. Whether it is the acquisition of milestones, the MA in relation to CA or the score in the different motor tests, almost all show greater variability in their outcomes, among individuals with DS. For the clinical surrounding this means that each individual must be closely examined for their potentials before any conclusions.

The most striking sign are a sort of clumsiness and an impaired balance. This makes movements appear unrefined, less coordinated and slow (B. Sacks & S. Buckley, 2003; D. Lane & B. Stratford, 1988). Surprisingly, these signs are noticeable although most children with DS acquire a sufficient level of motor control and are able to walk, run, swim and live independently to a certain degree.

From these starting points, some impairments and possible underlying theories that have been postulated are going to be looked upon.

**Balance** is what is defined as the ability to maintain the center of mass within the base of support. What contributes to balance is the vestibular system but also other sensory systems such as visual and proprioceptive feedback.

It is necessary to look at one specific research more closely. It is called the conflict technique. Matched infants with and without DS were presented with misleading visual sensory information. This created a discrepancy between misleading visual sensory information and vestibular information. All infants reacted on the visual stimuli but the DS group
reacted somehow more intensively. They swayed back, staggered, became generally unstable and/or fell. When both groups were able to walk (12 months of walking experience) the group of typically developing children did not react on the visual sensory information anymore. In comparison, even though they improved, the children with DS still reacted with compensation movements on the misleading visual sensory information. There were no practice sessions in between.

The authors of this study concluded that there might be a possibility that the vestibular system is not working efficiently at this point (B. Sacks & S. Buckley, 2003). Consequently they would rely more on visual feedback which is in this experiment most influencing. Other researchers (B. Sacks & S. Buckley, 2003) replicated this experiment but in sitting position and came to the surprising result, that infants with DS who had recently obtained the ability to sit unsupported showed less responsiveness towards visual-vestibular proprioceptive discrepancies than typically developing children. With experience the healthy children showed less intense responses towards the contradicting sensory information. The DS children did so in standing position as well but to a lesser extent. In sitting they did not show very intense responses in comparison and no significant change was noticeable with increasing experience.

The first conclusion was that in the early stages of the development of a specific posture, visual feedback is important but with experience the child becomes more and more independent and relies more on the vestibular sensory information which also means it learned to neglect the confusing visual information or to interpret it correctly. Secondly, as the response was generally more intense in standing in comparison to sitting, the conductors believe that visual-vestibular discrepancies have a greater influence on more unstable postures. This seems logic as more feedback adjustments and fine tuning of stabilizing muscles are necessary for those postures.

Many researchers believe that individuals with DS generally rely more on visual feedback than on other senses in comparison to their normal peers (B. Sacks & S. Buckley, 2003). The previously described experiment gives indications towards this assumption. Henderson (D. Lane & B. Stratford, 1988) categorically excludes the possibility that the motor problems originate purely from sensory deficits. Vision and hearing is not impaired or not in such a way that it could not be improved by aids, she says. However, research has also shown that these children have more difficulties in comparison to their healthy peers when presented with tasks that require visual discrimination abilities. Also J. Wendeler agrees that there is no visual impairment itself. Still, there may be a problem in the strategy adopted in how to extract the relevant information from the environment or there may be a problem in pattern recognition which usually accumulates with experience. It influences directly the manner in which sensory information is processed (Lane & B. Stratford, 1988).

When visual and tactile discrimination abilities were compared - and here the methodological difficulties such as the plain understanding of the task e.g. are being disregarded - many studies show that individuals with DS are better in discriminating when looking at an object than feeling it. Still, Henderson suggests looking closely at the
test-procedures. She argues that not one single study stated what the DS children and the healthy children actually did with the objects. Though in one specific study the children were guided around the shapes and were therefore able to discriminate as accurately as their normal peers. This finding also suggests that there is rather a strategy adopted which does not extract the relevant information from the environment efficiently than a purely tactile problem.

When Henderson excludes hearing as the source of motor problems she does not disregard the fact that children with DS learn quicker and better when visually instructed compared to spoken instructions (B. Sacks & S. Buckley, 2003). In this matter, J. Wendeler displays also comparable differences in the audio and visual memory which are of interest and to be kept in mind. The visual memory seems to be better than audible memory.

The information on proprioception is being disregarded as it is almost impossible to test pure proprioception and therefore it is impossible to draw any conclusions from the available data. Nevertheless, there are indications that proprioceptive feedback is very important for the refinement and subsequent automatization of movement patterns which is a particular weak point in children with DS.

The previously indicated issue of relying more on visual feedback than their peers is also supported by those who believe that children with DS are not able to form stable movement programs (automatization of movement patterns) (B. Sacks & S. Buckley, 2003; B. Lane & B. Stratford, 1988; J. Wendeler, 1988). A motor program is defined as a voluntary and conscious attempt to deal with the environment. It is the “integration of a set of previous independent but well learned individual movements into a sequence.” Once these movement patterns are consolidated they can be adopted easily to meet the environments’ exact constraints (B. Lane & B. Stratford, 1988).

The theory is that instead of having certain sequences of movements consolidated, DS children still tend to rely on sensory feedback more than their peers when performing certain motor actions. Fine motor skills are particular difficult for individuals with DS as they require a high level of refinement. This and the anatomical differences (smaller hands) are regarded to be the main problems associated with fine motor skills in people with DS.

A study that examined the particular way and how quickly individuals with DS placed different sized wooden rods into appropriate sized holes came to the conclusion that the topography (the grip) and movement abilities were the same as in typically developed children but it took them longer to select an appropriate strategy or response and it took them longer to organize this response. This is a sign for the above mentioned slowness in movements in individuals with DS. In most studies three kinds of tests are performed. “Tracking” – the subject has to follow an object at a predictable speed –, “tapping” – the subject has to do as many movements as possible in a given time, and “reaction time” (RT) – the participant has to respond as quickly as possible to a stimulus. First of all this RT does not stand in relation to the time taken to perceive a stimulus. It has been proven that a stimulus of the same intensity is as quickly being recognized by
DS children and as by healthy children. What makes a difference is the motor response connected to the sensory stimulus. Therefore the slow reaction upon a sensory stimulus is due to the planning period for the required motor response (J. Wendeler. 1988). This means that especially the “decision time” was longer for children with DS also in comparison to mentally handicapped peers.

On the movement time itself – meaning the time from the initiation of movement to the end of the movement – there is information that lets assume that DS children are slower than mental age matched healthy children but as fast as children with other handicaps. The “tracking” tests-results also seem to reveal problems in programming sequential movements (B. Lane & B. Stratford, 1988; J. Wendeler. 1988). All normal subjects and otherwise mentally handicapped participants performing in this test improved with practice but individuals with DS did not.

Last but not least the tapping tests did not display overall concordant results but Henderson concludes that children in DS seem to be slower than handicapped peers. With increasing speed, accuracy decreases and strength increases. In the book of Wendeler another study by Frith and Frith is mentioned in regard to the same tapping test. They state that since there is no learning effect in the simple movement of tapping, the result indicates in what way a motor plan has already been established or is being used for this specific movement pattern. They also come to the conclusion that individuals with DS do not acquire or do not use programmed movement plans and are therefore more dependent on immediate feedback.

Some authors simply constitute this lack of motor development to an apparently lighter brain, especially the cerebellum. The interpretation of this fact is difficult, just as it is to measure brain mass and makes the picture rather more undifferentiated than clearer Henderson states (B. Lane & B. Stratford, 1988).

7. Cognition in individuals with DS

The following section is about the cognitive abilities of people with DS. Many authors have stated that perception tests are difficult to interpret because the results may constitute for cognitive inabilities rather than mere perception abilities (Wendeler, 1988). This means that there may not be any sensory disorders but difficulties understanding the objective of the task, the goal or the problem they are to solve. Therefore it is also difficult to test cognitive abilities and to define what contributes to them. The following are abilities that have an influence to some extent on motor control.

The findings about concentration and attention differ. It has been reported that children with DS are initially quite active and are less able to concentrate. There follows a period of contentment and inactivity though. This happens once sufficient motor abilities have developed to interact to some degree with the social environment (Wendeler, 1988). Nevertheless, it is possible to draw a careful conclusion from one specific study (Wendeler, 1988). It suggests that children with DS lack specifically sustained attention which became apparent when compared to other handicapped and healthy children.

In reference to memory in children with DS, most studies regarded the short term memory and specifically the difference in the auditory and visual memory. The results
showed that in comparison to matched CA children their ability to store and reproduce was less accurate. It also displayed that in comparison to MA matched children, their visual memory was better than their verbal memory. This has obviously also to do with the often recognized speech problems. It can be correlated to the difficulty to contribute results merely to memory impairments, as “in people with Down syndrome it seems more related to difficulty in perceptual analysis than to malfunctioning memory processes” (Stefano Vicari, Giovanni Augusto Carlesimo, 2006). It becomes obvious that there is no consent about the findings among researchers.

In regard to mastery motivation many studies indicated that it is decreased in mentally retarded children. However it is not clear if this constitutes to environmental factors such as less expectations from carers and/or more failure experiences. A study by Sheila Glenn, Beverley Dayus, Cliff Cunningham and Maureen Horgan indicates that low mastery motivation is not inevitable in infancy in children with DS. Also it did not decrease over time. Thus environmental factors as such mentioned above do not seem to influence mastery motivation. Still, inactivity is an often reported symptom observed in children with DS as if they would lack motivation to explore their environment. It may have to do with the definition of mastery motivation that can be closely related to an attention deficit. (Sheila Glenn, Beverley Dayus, Cliff Cunningham and Maureen Horgan, 2001)

8. Development of speech and language

The information presented here below regarding general development of speech and language has been compiled from the following sources Lane (1988), Wilken (1979), Rondal (1995) and Bowen (1998). An overview of the speech development is difficult to produce since the norm is hard to define and the spreading is major within that range considered normal. Timelines can be given but should only be used as rough orientations. We will here offer a short overview on what speech is and its development mainly touching points that will be of importance later when we discuss the impact of different disorders present in individuals with Downs syndrome.

Firstly it is important to point out that speech and language are two different things, language can be divided into receptive and expressive language. Speech then belongs in the expressive part together with writing and signing. Understanding these ways of communicating is the receptive part. A language has rules for phonology, which is phonemes or speech sounds or in the case of signed language hand shapes, morphology which is word formation, syntax which is sentence formation, semantics which is word and sentence meaning, prosody which is intonation and rhythm of speech and pragmatics which is effective use of language.

Speech is sound produced by vibrating air that is forced to expire from the lungs passing the vocal cords in the larynx which frequency of vibration is determined by the action of the laryngeal muscles, stretching and shaping the cords. Then the air passes pharynx and travels through the cavities of mouth or nose. Movements of lips tongue and palate
influences the articulation of the sound while the shape of the mouth, nasal cavities, pharynx and chest acts as resonators also affecting the quality of the sound.

The language development has been a widely researched topic and there are many theories on how language is acquired and what precursors must be present and what influences the process. This is not the place for a review of this but we will simply point out that biological, environmental and social factors are matters of importance and that one of the questions discussed is whether the ability of developing language is or to what extent an innate ability in humans. The research on cognition is closely bound to the ability to acquire lingual skills. The development of languages follows a course and has certain milestones, in the table below is the most important of these ordered chronologically from birth until 5 years of age with both receptive and expressive language skills listed. As will be seen in later in the text where the disorders in Down syndrome this range is the most interesting for us to know when discussing this specific patient group.

<table>
<thead>
<tr>
<th>0-3 months</th>
<th>2-3 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Babies learn to turn to a parent speaking; they seem to recognise a familiar voice and will quieten at the sound of it if crying. Thy will also stop their activity and attend closely to the sound of an unfamiliar voice. He or she repeats the same sound a lot and &quot;coos and goos&quot; when content. Cries have different meanings.</td>
<td>Understands two stage commands (eg. Get your socks and put them in the basket) and contrasting meanings like (eg. hot / cold). The vocabulary develops immensely and utterances are usually one, two or three words long and understandable for family members. Can draw attention to and give objects attributes.</td>
</tr>
<tr>
<td>4-6 months</td>
<td>3-4 years</td>
</tr>
<tr>
<td>Respond to the word &quot;no&quot;, to change of tone in voice and to sounds other than speech. For example toys, music and rhythm. Gurgling sounds and speech-like babbling occurs and includes many sounds including the bilabial sounds p, b and m. Can use sounds or gestures to express wanting.</td>
<td>Understands simple questions (eg. who? and where?). Hearing difficulties may become evident in this age. Can combine four or more words. Speech is usually fluent and clear and understandable by others then family, talks about own day and experiences. Stuttering can become evident.</td>
</tr>
<tr>
<td>7-12 months</td>
<td>4-5 years</td>
</tr>
<tr>
<td>Recognises the names of familiar objects and begins to respond to requests and questions. Games like peek-a-boo are appreciated by the baby. The babbling includes more consonants and long and short vowels. He or she uses speech or other sounds other than crying to get your attention. Spoken unclear the first words appear.</td>
<td>Children in this age enjoy stories and can answer simple questions about them. They understand nearly everything that is said at home or at pre-school. Can construct long and detailed sentences and speaks with a clear and fluent voice and is able to tell a longer story using adult grammar. Most sounds are pronounced correctly, though e lisping and difficulty with r, v and th can be present. The child can communicate easily and even engage strangers in conversation.</td>
</tr>
<tr>
<td>1-2 years</td>
<td></td>
</tr>
<tr>
<td>Can point at pictures in books and a few body parts when asked, follow simple commands and understand simple questions. Enjoys listening to simple stories, songs and rhymes and wants them repeated. Vocabulary develops and makes use of 2-word sentences. Words are becoming clearer as more initial consonants are used in words.</td>
<td>Source: American Speech Hearing Association (ASHA), 2007</td>
</tr>
</tbody>
</table>
9. Disorders affecting speech and language in DS

9.1. Introduction
Language related deficiencies in DS are diverse and complex involving both organic malformations and difficulties affecting speech and disturbances in central processes of a cognitive nature affecting information processing, attention capacity, reaction time, auditory-vocal processing, short-term memory, retrieval from long-term memory, perceptual discrimination, symbolization capacity and abstract attitudes. With this list of factors impeding language development it seems a wonder that language skills actually do develop in DS individual. Rondal (1995) sees this as an indication that the basic language organization in humans is quite robust.

9.2. Anatomical influences on the “speech-organs’

9.2.1. Lips
Castillo Morales (1991) reports in his observations that the upper lip only shows minimal movement while the still hypo tone under lip in comparison to the upper one is very active. The upper lip is described as thin, Wilken (1979) refers to Langdon Down and his observations in where the under lip is described as wide and thick with vertical fissures. Wilken (1979) further refers to Penrose’s discussion on the reasons for these anomalies, which are seen as secondary problems to the mouth being held open and to the habitual protrusion of the tongue which then causes and excessive amount of saliva on the lips and cause them to dry and crack. Castillo Morales (1991) also points out that the under lip is gradually turning itself inside out as well as getting more and more hyper toned and eventually in some cases it can lose its function. Cases where saliva, nutrition rests and fissures accumulate in the corner of the mouth disturbing nutrition and articulation in such a degree that operative intervention was performed have been observed. The cheek muscles are hyperactive due to the protrusion and turning inside out of the under lip, since they always have to pull up the under lip during activities like swallowing. Wilken (1979) found that 21.6% of the parents reported fissured lips as a problem.

9.2.2. Teeth
Wilken (1979), Rondal (1995) and Castillo Morales (1991) all reports about different anomalies and late development of the teeth. Wilkens (1979) says that the teeth are considered to be microdontic and to show abnormalities of shape, such as being pegged or having malformations of the crown. Hypoplasia and hypocalcification of parts of the teeth is frequently observed by Castillo Morales (1991) and he also refers to observations from Benda that the teeth are crowded or sometimes abnormally widely spaced and normal alignment is rare, the absence of teeth is established and the mongoloid teeth are smaller and frequently abnormally shaped. Benda explains these anomalies through a deficiency in the thyroid gland. Gibson (1978) shows that crown abnormalities are found 29 more times in a DS population then in a normal population, further he discusses the impact of these findings by quoting Buddenhagen (1971) “while abnormalities in crown
morphology can have little effect upon the articulation of phonetic behavior, the absence (either from extraction or delayed eruption) and irregular alignment of teeth certainly do. And if the incidence of such flaws parallel that of crown abnormalities, the expectation for a normal development of speech would be seriously challenged”. Further he gives an example where the absence of the incisors distorts the sibilant sounds (f,v,d,o) and also lists several other sources with similar findings, eg Strazulla (1953). In the parental questionnaire by Wilken (1979) 56.8% reported these anomalies as present in their child.

9.2.3. Jaw
In the child with DS the upper and lower jaw has a good position, during the development the position is changed and the lower jaw shows prognathism, which will impair articulation later on according to Castillo Morales (1991). Wilken (1979) reports this in 16.8% of the subjects and explains the reason for the mal position through the absence of counteraction from the upper jaw, which is described as too small, under stress of abnormal muscle pull.

9.2.4. Palate
The palate is reported by Gibson (1978) as to small for the tongue and its shortened cavity as a reason for distorting the configuration of the vocal tract from the lips to pharynx. Wilken (1979) describes the mouth (buccal cavity) as being too small and the palate as high and narrow, however measurements shows that the palatal vault is not abnormal if the diminished size of the bones of the skull is taken into consideration according to Penrose (1966), it is very discussable whether this is of any importance since the shape and size of the palate is still a fact and its characteristics has an impact on the voice and articulation. Castillo Morales (1991) points out that the palate develops disharmonic and forms a groove in the shape of a horse shoe with hypertrophy of the mucosa in the palate. Rests from eating can accumulate in this groove in some extreme cases. The patients show large disturbances in the articulation with a characteristic nasal tone.

9.2.5 Tongue
The tongue is too big for the oral cavity and protrudes out of the same; therefore it may appear that a hypertrophy of the tongue is present. But this is not necessarily the case it may appear so in relation to other structures around that are under dimensioned (upper jaw, nose and lower jaw), Rondal (1995), Gibson (1978) Wilkens (1978). Bierich (1975) states the same but points out that a macroglossy can develop in the late childhood. So hypertrophy of the tongue is present in some cases, the reason for the hypertrophy is not known but the papillary hypertrophy is explained in Wilken (1978) by the excessive sucking of the tongue. Gibson (1978) and Rondal (1995) states that the tongue becomes edematous due to the protrusion. The tongue lies upon the lower row of teeth and the vestibular side of the lower lip, in older patients the teeth can have formed grooves in the backside of the tongue Castillo Morales (1991). The tongue can get the structure of a land map. Diastase of the tongue can be seen in form of two grooves running parallel and
possibly connecting at the tip of the tongue, in between the two grooves a plateau is present, the grooves can only be observed when the tongue is active Castillo Morales (1991). The edematous and fissured tongue does not groove properly for distinction between sounds Rondal (1995). Castillo Morales (1991) also states that the bands of the tongue are often hypo plastic. The hypo tone of the tongue gives not only a floppy appearance but influences also the articulation of the speech greatly Wilken (1978) Castillo Morales (1991) Rondal (1995) Gibson (1978) Bierich (1975).

9.2.6. Larynx
Wilken (1978) recites the view of the Larynx anomaly in DS from König (1959) in where it is stated that the larynx is underdeveloped and comparable to the larynx of an embryo. Other authors does not report such immense deformations, however both Rondal (1995) and Gibson (1978) reports a high position of the larynx in the neck and a thickening of fibrotic mucosa.

9.2.7. Nose
A flattened nose is mentioned by many authors as a characteristic of the child with DS, Penrose (1960) states that can be considered small in about half of the cases with the cartilaginous part being wide and triangular producing a “pug-nosed” appearance. The reason would be the disharmonic growth of the skull bones causing the distortion of the proportions in the face as well as the held back growth of the upper jaw causing the mal position in relation to the further growing lower jaw. This also impairs the growth of the sinuses and nasal passages according to Rondal (1995), Wilkens (1978) and Gibson (1978) who also reports of the absence of the frontal sinus in some cases. This impairs nose breathing as well as it affects the tone and articulation of the child’s speech. Castillo Morales (1991) points out that a total absence of nose breathing can be of hindrance great hindrance in any therapy.

9.2.8. Breathing
Many DS children has a compromised breathing, this can be explained by a few different aspects present in the child that together adds up to this phenomena. Gibson (1978) and Rondal (1995) mentions hypotonic breathing muscles, structural anomalies in the thorax (eg. diaphragma diastase), hypertrophic tonsils, adenoids and polyps, common respiratory infection, frequent inflammation of the pharynx, laryngitis and bronchitis. Both Wilken (1978) and Castillo Morales (1991) states that the vital capacity of the child is considerably reduced due to the frequent infections and inflammations. The reduced nasopharyngeal passages forces some children to breath with open mouth at all times and therefore develop edema and dryness of the mucosa. This can lead to a more susceptible environment for infections. In Wilken’s (1978) report 26.5% of the children had a lung inflammation and 46.5% had bronchitis.
9.3. Other physical disturbances

9.3.1. Hearing
In Pueschel (1987) Miller writes that hearing loss always gives problems with language learning, he also connects the frequent middle ear infections in the DS population with the impaired language development. Both Rondal (1995) and Gibson (1978) refers to a study by Rigrodsky et al. (1961) which compared hearing loss across several types of mental retardation and they found that in the DS population hearing loss was much more common then in normal children and appreciable then other groups. 60% of the DS subjects suffered from hearing loss, mainly in the range slight to moderate. Wilken (1979) reports several different sources investigating the hearing loss in DS patients. A great variety seems to be present with some authors stating that the hearing is normal while others report about high percentages of patients with hearing loss. The variety in the DS population together with methodological differences in the studies and the exclusion criteria’s of subjects explains the differences and once again points out to us that it is difficult to generalise within this patient population since the individual differences are so vast. Rondal (1995) refers to Ferri et al (1986) who found numerous patients showing brainstem conduction dysfunction that appears to be connected to the degree of mental retardation.

9.3.2. Visual problems
Language learning involving visual attention is disturbed in subjects with any ocular defect. In DS patients’ strabismus, myopia, cataracts, nystagmus and lens opacities are well known and occurring according to Gibson (1978) and Rondal (1995). Watering eyes, conjunctivitis and respiratory infections should also be taken into account as factors disturbing the visual function of the patient.

10. Articulation
One of the most common and clear problems in DS patients with speech disorders is the articulation. Wilken (1979) points out that next to the mental factor there has to be another factor playing a role in this matter. She suggests that the many anatomical anomalies have an influence and then in particular the hypotone tongue. She points out that the child that lies has a guttural sound while the crawling child has more of an interlabial sound production, just as if the tongue slips back/forwards depending on the force gravity. Wendeler (1988) reinforces the belief that the tongue has an influence on the articulation and refers to Olbrisch (1982) and Parson et al (1987) that showed that a surgical approach by shortening the tongue gave improvement in articulation and speech according to parental questionaires. Parsons et al (1987) performed a trial on this matter and reached the opposite conclusion with objective measurements instead of subjective parental questionnaires. Wendeler (1988) also reports the work of Dodd (1975), Dodd bases on studies showing that the articulation problems are irregular in relation to the language development and therefore not connected as one would expect. Dodd excludes
the anatomical explanation to the problem and focus on two other causes, namely firstly the audio processing and saving and secondly the ability for motor programming of speech. In an experiment she has 10 children with DS and 10 children with other mental retardation to listen to three different speakers asking them to recognize a word or to reproduce it, with or without a 15 second delay. There were no significant differences in recognizing words between the groups or the delay or in reproducing a word directly. But when the subjects were asked to reproduce the word after 15 seconds many failed. This shows that there were no motor hindrances performing the differential movements the speech required. Dodd then draw the conclusion that the cause of the problem lies more in the ability of the DS patient to remember how the sound is produced and that this problem didn’t exist when echoing the word.

11. Phonation
The voice in DS patients is very characteristic and Benda (1949) even goes as far as saying “the diagnosis of mongolisms can be mady by hearing the voice without even seeing the child”. Benda (1949) lists authors describing it as “hoarse and unclear” (Langdon, Down, Geyer, Hintze, Schroeder), “unrefined, raw and not modifiable” (Koenig), “hoarse, deep and male” (Benda, Wiegand) and “guttural” (Benda, Penrose, Bourgin, Johnson, Wechsler). Wilken (1979) quotes Kainz “Die Rauhigkeit und gutturale Faerbung der Stimme ist auffallend und diagnostisch verwertbar.” (trans.“The roughness and guttural coloration of the voice is remarkable and usable to diagnose”. In Wilkens study 60% of the parents reported their child’s voice as normal while 16.8% called it hoarse and 31.4% as deep.
The cause is not known and the despite efforts by many authors they shows great variety in their theories and explanations. Some authors see the high position of the larynx together with the thickened and fibrotic mucosa as a possible explanation together with the absence of sinus formation and myxedema of the larynx. Thyroid insufficiency has been suggested and treatment of such showed increase in general well being but not any significant improvement in speech. Bendas (1949) observation of the underdeveloped and high positioned larynx was supported by investigations of bones from Neanderthalss who also had similar anatomy to the DS children. The characteristic voice has also been explained by irregular and/or dysfunctional breathing and general hypotone also affecting the larynx and the vocal cords. This together gives a collected picture of the characteristics of the voice but the explanations for it diverse widely between authors.

12. Flow of words
Gibson (1978) accounts for several authors looking in to the flow of the speech in DS children, they found speech blocks, cluttering and stuttering within their subject populations. No reason for these disorders were accounted for, Gibson only states that biogenic and psychogenic factors possibly operate independently. Wilken (1978) accounts for a clear increase of stuttering in any mental disorder, DS in its turn shows a double incidence compared within these groups. Some authors beliefs psychological factors and fear to be the reason for the disorder while others tries to explain it differently
since they found a difference between stuttering in healthy individual and individuals with DS. Cabanas (1954) find the cause for overstressed, repetitive and blocked speech in the lack of vocabulary and the disharmony in the cognitive imagination and motoric skills in the speech organs.

13. Language development

13.1. Vocabulary
The onset of the first meaningful words is delayed in DS children with them often being recorded between 24-30 months according to Rondal (1995). DS subjects compared with normal develop children matched with mental age and not chronological show a similar pattern in their vocabulary with them first acquiring social words and a few objects and then later on relational words and more objects.

13.2. Semantic structures
DS children start to combine two or three words around 4-5 years chronological age (sometimes later), and it seems that they express the same relations, roles and meanings as normal developed children do in their early language Brown (1973). It is also important to point out that their structure follows the natural languages and they also understand the same structure when spoken by others Rondal (1995).

13.3. Grammatical development
This can be measured by the mean length of utterance (MLU) of spontaneous speech. The grammatical development is never complete in DS subjects, progress is however observed in MLU with increasing chronological age Rondal (1995). Again it is important to stress that the structure developed in the language of DS subjects follows the normal development but that the subjects use less complex sentences Lane (1985). Chipman (1981) assessed the knowledge of grammatical rules by giving the subjects a task which they had to act out the meaning of the sentences with toys. The understanding of the sentences was similar for the normal develop children and DS while the acting of the same showed more variability. Lane (1985) interpret this as the DS subject follows a normal progress from one word utterances to complete adult grammar, however the syntax is less complex in every stage of development and the repertoire used in active language is limited.

13.4. Pragmatics
In the later research the pragmatic skills of the DS subjects gets more and more attention, this seems a very reasonable and functional direction since the ability to communicate and have a flowing and enriching conversation after all the main goal behind language and speaking. Rondal (1995) states “Although formally reduced, the language of DS
individuals is not devoid of communicative value” and Bolognini et al (1988) writes the following “Conversational topics are dealt with in such a way as to allow for the necessary continuity in the exchange between interlocutors. Language content is informative and new information is exchanged”. Leifer & Lewis (1984) did a study comparing a normal develop group of children in aged between 18-23 months with one group of DS subjects in with the same chronological age and one group DS subjects with the same mental age. The subjects were studied in a 30 minutes free play session with the mother where the reactions from the child on the mothers input were judged. Important point is that reaction was allowed to be either speech related or non-speech related. As expected the normal children reacted better then the chronologically matched DS group, but interestingly enough the mentally aged matched DS subjects reacted better. The conclusion from the authors came down to that the receptive skills are further developed then the expressive skills which is explained by that even though the child is stuck the one word step in the development its skills in mutual communication develops further. This offers a part of the explanation to the phenomena of DS subjects able to integrate socially despite their difficulties in expressing speech.

13.5. Cognitive development
Rondal (1995) discusses the view on the development and limits of the mental development in individual with DS. It is generally accepted in the literature to give the DS a maximal level of around 4-5 years of mental age which is being develop and culminates around 10-15 years of chronological age. During these years the development follows three stages of which the first one consists of the first 18 months of mental age in which the sensomotoric intellectual subcategories of Piaget is observed until 4-5 years of chronological age where it ends. Then the second and third phase follows where year 2-5 of mental growth occurs during year 5-15 of chronological age Gibson (1981).

Although the articulation is the most characteristic and obvious affected language skill in DS children other skills are also affected to a lesser extent, still compared to other areas the development is impaired and slow. Perception skills are representative for cognitive skills and can be used to compare the level of development between language and cognition. Schamberger (1978) showed that until the 20th month of chronological age the language and cognitive development didn’t differ but after this point in time the cognitive skills were further developed then the language. Mahoney et al (1981) confirmed this when comparing children’s expressive and understanding language skills with an average of their cognitive age around 17 months. He found the DS subjects to be at the level of 13.5 months in their expressive skills which means that the first words with meaning were showing. The normal subjects where at a level of 16.5 months and therefore enriching their vocabulary while the DS children still were learning the meaning of their first words. Mahoney concludes that DS children stays further behind in language skills then in other skills at around 1 ½ years of age and that this coincides with the time that the children starts to give their sounds an actual meaning. Further both authors suggest and other has shown that the difference grows during the other half of the second year of living. Wendeler (1988) describes a study from Cardoso-Martins et al (1985) which confirms the above mentioned findings and conducts a study with the framework of Piaget’s development theory. Piaget’s theory says that after the sensomotoric
development the first steps of abstract intelligence development takes place. Speech is already available but becomes only active in the second half of the second year of life when it is needed for the further development of the abstract intelligence. DS children were matched with normal children according to their developmental age (cognitive) and their speech was compared. When the subjects were in the last step of the sensomotoric development (and no abstract intelligence present) the difference was small. The DS subjects mastered two words on average while the normal subjects mastered four, however when subjects being in the first step of abstract intelligence development were compared the difference was 9 words for DS and 17 for normal children. From this follows that the further development from one word utterances to two/three word sentences is greatly delayed since observations have showed that this step in the language development can only be taken when the child masters a great enough vocabulary usually acquired in clear phase of development. The reason not being led back to functional, anatomical or motoric disturbances of the speech organs since the speech impairment would have been observed in an earlier stage. Further Wendeler (1988) states that the strong delay after 1 ½ year can not be explained by these impairments of the speech organs and therefore must originate in the central cognitive processes in the DS child.

13.6. Language understanding and expression
Language skills must not be the same as the ability to express the same. Often the expressive and perceptive skills in DS subjects are assumed to be of different quality and the perceptive skills are even assumed to be normal even though the speech skills are weak. This is difficult to show since perceptive skills are difficult to study. The fact that DS children often uses gestures and mimic where their speech skills come short is not enough since this is also present in normal children. A difference between DS children and normal children could show this. Schamberger (1978) was able to do so, but the difference found was not great. Cunningham et al. (1985) conducted a longitudinal study of DS subjects with an average age of 41.1 months where the mental age, speech age and language understanding age was compared. The mental age was found to be 23.5 months, the speech age 19.0 months while the language understanding age was 22.3 months. So there was obvious difference between speech skills and understanding while understanding almost but not completely matched the mental age. It is however important to realize that even though the understanding is well developed compared to speech in DS children the understanding is poorer then in other mental handicaps Wendeler (1988). Hartley (1982) explains this by the processing of simultaneous and successive information. DS children show weak ability to process successive information and since most information in speech is successive they would have difficulties.

13.7. Non-verbal expression
Many authors describe the use of mimics, gestures and other manual expression skills used by DS children as compensation for their lack of speech ability. Wendeler (1988) refers to Rohr & Burr (1978) who compared different language abilities in children with four different mental disorders. The only skill where DS subjects scored as high or higher then the other groups was manual expression skills and in no other group the difference
between manual expressive skills and speech was as big as in the DS group. This finding also supports the statements in the above section.
Second section

14. Psychomotor Performance Therapy (PPT)

Psychomotor Performance Therapy has an integrated view of behavior organization as a basis. This means that several aspects interplay to form a well structured and well behaving individual. Therefore the focus of this therapy lies on the overall development of a child and not on separate abilities. Nevertheless, three levels of how to approach a child’s disorders have been proposed only due to didactic reasons (E. Kiphard, 1990):

- Perception
- Motor action
- Emotional-social behavior

As stated before, Perception and the “adaptive” motor behavior go hand in hand. They stand in a reciprocal relationship to each other. The development of one system supports and guides the development of the other.

Psychomotor Performance Therapy comprises another aspect though, that of emotional-social behavior. This is done in order to comprise the emotional side of every perceived stimulus and its adaptive motor response on the one hand. On the other hand it also targets the harmonic interaction with society. Therefore the process of individualization and socialization are of specific interest in Psychomotor Performance Therapy. The child is to form its own personality and find out about its own abilities on a motor and cognitive level.

Thus, the focus of this therapy is on the sensory system and the integration of the different sub-systems, the motor system and the resulting emotional and social behavior exhibited by the child. All of these points stand in close relation to each other. Motor and sensory impairments are regarded as primary problems and the subsequent behavior, secondary problems. However, secondary problems can further hinder the development of primary problems.

<table>
<thead>
<tr>
<th>Neuro-motor problems</th>
<th>Sensorimotor problems</th>
<th>Psychomotor problems</th>
<th>Social-motor problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient movement patterns</td>
<td>Insufficient perception</td>
<td>Insufficient/inadequate movement behavior</td>
<td>Insufficient/inadequate social behavior</td>
</tr>
</tbody>
</table>

Source: Kiphard, 1990
14.1. Indications for PPT
In a clinical surrounding PPT has shown to improve a number of handicaps or behavioral eminencies. Mild cerebral palsy, persisting symptoms after the application of an early intervention or general motor problems are some of them. It further includes sensory integration problems, speech problems or children with multi-handicaps (Mehrfachbehinderungen), syndromes (e.g. Down Syndrome) or learning or behavioral disorders (such as: ADHD, concentration problems or aggression and other misbehavior). (Kesper G., Hottinger C., 1993)

14.2. Clinical observation principles
During the observation the perception abilities and the motor performance abilities are examined. Also the quality and quantity of the child’s strategies to achieve a specific goal but also the general behavior exhibited by the child are matter of the observation.

Motor wise tonus, associated movements, the determination of the dominant side, coordination, side-differentiation (hemi-symptoms), how the child holds a pen and the way it articulates itself are to be noted.

The way the child finds solutions to presented problems but also what mechanisms it uses to avoid problematic situations and how it generally reacts to failure can give important information to the therapist.

Further, the level of understanding and conversion of verbal commands, attention, attention endurance and general motivation can give indications for the subsequent intervention.

However, mere motor symptoms or behavioral problems do not give any indication for an intervention. The sensory integration impairments, the motor problems and the conspicuous behavior must correlate to each other. They must all be seen in one common context in order to come to the conclusion to administer psycho-motor performance therapy.

14.3. PPT – Sensory integration Therapy
Principles

The sessions should always have a clear structure and an always returning order. This structure will help the children to consolidate their inner order which is usually impaired in children with sensory integration problems. Especially in the beginning of the therapy, structure is very important. With the improving adaptation abilities this structure can slowly be released.

The goal of a task must always be clearly understood by the child. Therefore, the exercises must match the child’s level of understanding. To make it easier sub-goals may
be formulated to bring the child step-by-step closer to the main goal. Demands may certainly not be too high either since especially success is a good tool for motivation.

Misbehavior may be an indication for too high demands or an indication for an inconsistent neural integration. In this case basic exercises that stimulate the tactile, kinesthetic or vestibular system are to be considered more thoroughly.

To increase the adaptation abilities, motor and perception skills should be practiced in various situations to achieve a generalization. Therefore the therapy should contain transferable and association exercises.

The rules that are applied to everyday life should also be followed in the sessions. The therapists’ behavior must be clear and predictable. The mimic and verbal communication must always correspond. At the same time the behavior must project calmness and security.

14.4. Therapy Goals
The main goal is the expansion of the qualitative and quantitative motor abilities. This is achieved by the completion of the motor and perception integration.

The overall improvement is noticeable in a better self awareness, self confidence and a better control over its emotions.

Social integration becomes a central issue of the therapy once the child experiences itself and has control over its emotions and behavior.

The focus on perception and motor abilities and especially the development of the vestibular system nourishes the ability to sustain attention and concentration. This is part of every session and it increases the receptivity of the child for other exercises.

The success of the therapy is observable in newly acquired movement patterns and a better behavior. Mostly, the adaptation of children, transfer of movement or behavioral patterns to other situations in an adequate way, is considered a successful sensory integration and a successful sensory interpretation.

14.5. Psychomotor Performance Therapy in DS children
Initially the therapy targets the presentation of their motor symptoms. Besides the motor symptoms mentioned in the previous part about DS, they also frequently present body scheme disorders, in the bilateral exercises and when crossing the midline. Further, hold- and support-functions of hands and arms are badly developed, as is their speech.

Besides the basic exercises, the kinesthetic perception (compression and traction exercises) exercises and those for finger and feet are part of the entire therapy process.
Crawling, the hold and support-functions of hands and arms, and further locomotion exercises have often achieved good results. It has been shown that the groups can vary greatly in age (4-7 years of age), and that these children can easily be integrated in groups with children without handicaps or syndromes (Kesper G., Hottinger C., 1993).

15. Neurofunctional Reorganisation according to Padovan

15.1. Introduction
To give a complete view over the Neurofunctional Reorganisation according to Padovan we will give short insights into the works of other authors. Mrs. Padovan bases her therapeutic philosophy on those authors writings. They are Rudolf Steiner a German philosopher and pedagogue and Temple Fay an American neurosurgeon. In addition to that she makes use of recent knowledge about the neurological anatomy. We will use the description of this area written down by Nelson F. Annunciato a professor in Neurological anatomy. In to addition to these points comes also the natural development of the human being. In order to understand the Neuro Functional Reorganization according to Padovan it is important to know its origin. To enable the reader to do so we will now give a general outline of each one of these pillars on which the NRO according to Padovan rests on and then describe how these have been combined into form this therapy. Although it is not the aim of this paper to train any therapist in this technique we will also say something about the practical therapeutic exercises used. Everything written here below has its sources either in articles published from Mrs. Padovan or texts from Mrs. Padovan where she interprets or sums up the works of the individuals accounted for above or the actual literature from the same authors, all are listed in the references.

15.2. The natural development of the human being
“The one who follows what nature teaches us doesn’t fall so easily into confusion.” is a statement from Mrs. Padovan which shows what approach and attitude towards the natural development of the human being and its skills and qualities the therapy has. Mrs. Padovan describes the development of a seed which is planted and there after grows and acquires its very own characteristic and in the end develops seeds identical to the one it self grew from to show the genetics in development. Everything living follows this path and so also humans, we can predict that the new born baby will acquire the characteristics of an adult. Mrs. Padovan points out that there is always changing occurring in the human being from being conceived until dying, motor, linguistic, intellectual, emotional and personal character all changes depending on what we experience and learn. Constant change is one of nature’s laws.

During the maturation of the CNS the child acquires all qualities that belong to its predestined and typical human program. Sensorimotor, cognitive, learning, language and communication abilities all develop parallel to each other however they become
noticeable after one another in a clearly successive manner. The ability of movement is already present during embryonic life and even noticeable by the mother by the second month of pregnancy and they are essential precursors of embryonic development.

Just as every stage of embryonic development can be damaged or affected by different factors so can also the maturation of the CNS and with it the entire developmental system. At the time of birth the child is equipped with a number of infantile reflexes that results in automatic and stereotype movements that are executed by the brainstem and cares for the infants’ survival in the first weeks of life. Thereafter they should be controlled or inhibited by the higher centers in the brain. Through this a higher development of the nervous system is possible and the child is allowed to take control over voluntary reactions. Inhibition of such reflexes are often connected to the development of a new skill, if an infantile reflex stays to long it will be considered abnormal and indicate structural weakness or underdevelopment of the CNS.

15.3. The relation between walking, speaking and thinking according to Rudolf Steiner

Rudolf Steiner says that these three activities define the human being: “Man is the only being that walks erectly, uses a codified language and elaborates ideas, in other words, a thinking being.” Steiner’s way of characterising each one of these activities is important to know and understand in order to understand Mrs. Padovan’s work.

Walking is a complex motor process that leads to the consolidation of the laterality. Walking is connected is to a displacement of one self in a state of equilibrium across the entire space, to learn how to walk means to find the directions of space and to be able to find these direction in your own organism when in space. To develop the erect bipedal gait the child has to struggle against gravity and impose its body into space with balance and harmony, controlling every movement. The child has to go through different phases of development, rolling, creeping, crawling to be able to walk. All these phases are inherent to the very human nature and are reached through impulses sent by the body. Since they belong to the human genetic program they are bound to be important to the child’s development and in fact they must be completed in a natural way without forcing it in order to reach what the human nature is.

Speaking has its origin in the process of spatial orientation of the human being, as written above this means the development of walking and the entire motor system of the child. The lateralization and the speaking are in close relation to each other. The beginning of formation of the lateralization in the cortex is decided by a phase of development and coordination of the muscles. As with walking every movement of the speech organs requires the participation of the voluntary musculature, so when learning to speak the child’s entire motor system is involved. Speaking requires the participation of the most demanding and fine motor skills that the human being disposes. The development of speech goes through phases just as walking does, screaming, crying, babbling and stuttering until the child acquired a well and structured language.
Thinking is a mental process that develops from language. Language is the instrument by which we can express thoughts but we cannot think without language, the native language forms the thinking. When the child starts to name beings and objects inner mental pictures are formed and saved in the memory. When a conversation takes place these pictures will be associated with each other and make the formation of thoughts easier. Thinking has the following phases of development: fantasy, observation, conclusive thinking and ability to judge. Thinking is not only the ability to formulate ideas but also as the ability to learn and to adapt oneself to one’s environment. Mrs. Padovan uses the famous example of the wolf-boy to illustrate this. He lived with wolves and learned their behavior, comparing this with a cat living amongst humans the difference is clear. Humans are able to adapt and need the right environment and stimuli to develop effectively according to their genetic program.

Walking, speaking and thinking all relate and depend on each other as well as developing next to one another. Each phase and its respective age have predominance and there is a precise order of when these activities are acquired and noticeable. Another famous development theorist, Jean Piaget, writes “the sensorimotor intelligence, which comes before language, prepares, on the elementary action field, what will later on become reflected thought.” and “… language develops itself in a certain way and only becomes thought when the last is able to allow a transformation to occur.” Steiners walking is Piagets sensorimotor intelligence, speaking is language and thinking is reflective thought.

15.4. Neurological organization and reorganization according to Temple Fay
Temple Fay was an American neurosurgeon who was active during the Second World War together with his colleagues Glenn Doman and Carl Delacato studied the human development. Besides their own personal experiences they used the work of Arnold Gesell on the development of normal children. Fay states that the developmental history of an individual organism (ontogeny) recapitulates in certain aspects to the whole evolution of a species (phylogeny).

This development he called Neurological Organisation, which also was the process that humans went through when getting into an upright position. Delacato defined the Neurological Organisation as a physiological optimum condition that is only achieved in human beings as a result of an uninterrupted ontogenic neural development. This development recapitulates the phylogenic neural development. The same development happens in all mammals but in humans the process continues also vertically through the CNS and up to the cortex. In man the final stage of development is the process of lateralization which can go from right to left or adversely, this stage is exclusive for man. Another exclusive skill for humans is language; he goes as far as saying that in order to be totally human he needs to be able to make use of language. Language is the result of the phylogenic development of the nervous system. “Language, in an individual’s development, is a result of the developing and organisation of his Nervous System.” (Delacato)
Mrs. Padovan simplifies this last statement as language being a result of the neurological organisation. And since Neurological Organization was described by Fay as the ontogenetic development where the child goes through phases before achieving an erect position and move, in fact walk, this is a precursor of language.

Temple Fay and his colleagues noticed that normal children made the same stereotyped movements’ regardless race; ethnicity or geographical location. He also noticed that children with brain injuries couldn’t make these movements properly. The movements were named “patterning”. Fay started to help the patients performing these movements in the same sequence as in normal development on patients, conscious or unconscious about the movement, in the hope that the CNS would learn them and perform them naturally. They found this to be case and further that the learning of the patterns in some patients was like removing a blockage in the patients’ development which thereafter would continue. With time more movements belonging to the natural development were added. This process of ontogenic recapitulation of organization was to be called Neurological Reorganisation (NRO).

15.5. Neurological plasticity and its therapeutic use described by Nelson Annunciato

The ability of the nervous system to adapt and recover is called plasticity. We will now discuss this character and its possible use in therapy.

After the end of individual development no more nerve cells are produced in any mammal. This gives the idea that the nervous system is static, fixed and lacks ability to recover. It consists of a complex network on microscopic level with multi faceted structure of connections. When the nervous system changes, recovers, it must therefore be due to the changing of the connections in this complex network.

Plasticity is a process that not only occurs with pathologies, it is an important part of normal development and functioning of the human organism. For example it is important in the formation of neurological connections during the prenatal phases and the ontogenic development since many of these connections has not been genetically programmed. Different kinds of plasticity are known, epigenetic factors (all factors not belonging to genetic programming i.e. external stimuli) and learning processes like unconscious motor learning (automatism) and conscious learning (memory). These processes depend on similar physiological mechanisms and form a base for a normal development of the nervous system as well as for a recovery after an injury to the same. What makes these processes interesting is the fact that they are influenced from stimulation of the peripheral nervous system and then affect the CNS.

The conclusion drawn from above is that with the right amount and kind of stimuli the nervous systems connections can grow and find better and more functional connections.

To optimize the therapeutic effect it should be implemented as early as possible due to the fact that 60 % of all produced nerve cells degenerate. This happens when they do not
close any connection with the periphery from where they should receive their nutrition (neurotrophic factors) via the axons. In order words the stimuli supporting development and forming of new connections should be given as early as possible.

15.6. Padovan’s extension of NRO to vegetative reflex functions

Mrs. Padovan is a speech therapist and missed something in Fay’s NRO. She noticed that her patients with speech problems or loss of speech had not developed the pre linguistic factors respiration, suction, mastication or deglutition properly or at all. These factors are called vegetative reflex functions. Fay suggested that when a step in the development is missing you should exercise the precursor of that step; Mrs. Padovan now implemented this into the speech therapy exercising these precursors of speech instead of speech itself.

Every movement executed on the NRO’s exercises belongs to the human genetic program giving proprioceptive information to muscles, tendons and joints. Looking at the sensorimotor homunculus it is clear that the mouth area is extremely rich in both extero- and proprioceptors. Therefore the introduction of vegetative-reflex functions complements in a significant way the original version of NRO according to Mrs. Padovan.

Mrs. Padovan applies anthroposophist philosophy, with its roots from Steiner, to her therapy. It is known as Waldorf pedagogy and it says that everything has its own time and therefore its right moment to develop each activity. Mrs. Padovan always respects a child’s neurological maturing time and takes good care to follow the evolutionary phases. Therefore knowledge of these phases is essential and Mrs. Padovan suggests that Gesell’s work provides the most complete reference.

In the sessions Mrs. Padovan’s starting point is the new born child, its position (prone) and its movements, and then following all the natural evolutionary phases in each therapeutic session. She refers to Bekey’s statement about the CNS, “CNS is a complex intricate of feedback circuits. If we send more primitive impulses, other paths will open and new circuitry may be formed.” This stands in contrast to Doman and Delacato’s work where they simply starts each session at the level below the development stage with a disturbance.

15.7. The exercises

During the session a parent usually the mother is present if possible; it eases the child's anxiety and can help the therapist to understand the child better. The parent can also be of assistance in the therapy. The exercises are combined with the singing or telling of verses to bring rhythm, induce vocabulary, phonemes and thinking. As stated earlier it is not the aim of this paper to teach the practical part of this therapy. The sequence of the exercises is repeated during each session according to a strict protocol. This protocol follows the ontological sequence from creeping to walking. It includes the crossing of the midline, it stimulates the vestibular system and strengthens and mobilizes specific joints and
muscles which are of particular importance. These are just some examples of what this therapy does.
Third section

16. Pilot Study
In section one, we described the problems of motor and speech development in children with Down syndrome and their influences on life in the individual. In section two, Neurofunctional Reorganization according to Padovan and Psychomotor Performance Therapy were presented. They are commonly used to treat children with DS, at an age when these two areas of development are of particular importance. In this third section we will present our pilot study. The purpose of this study is to portray a design necessary to evaluate the efficiency of the interventions.

16.1. Introduction
This pilot study aims to reveal pitfalls and other problems for a future long term study. We recruited 10 children diagnosed with DS. Half of the children received Padovan and the other half Psychomotor Therapy during the 10 weeks of this study. We measured motor and language skills with standardized tests at the beginning (T1) and at the end of the study (T2). We were interested in three aspects. First, we analyzed the results of all ten children, regardless of therapy, on their progress over the ten weeks. Secondly, we separated the results into motor and speech dimensions. The results of these dimensions were compared to the general findings of the literature portrayed in section one. Thirdly, the measurements from T2 of the two intervention groups were compared to T1 to see if any improvement occurred. Our hypothesis was that no differences would be found in motor or language skills in the entire population, the Padovan or the Psychomotor group comparing T2 to T1. Our second hypothesis was that no differences would be found between the motor and language abilities of the subjects participating in this study and that of individuals with DS described by the literature in section one.

16.2. Method

16.2.1. Study design
The study consisted of two groups with five children each, one receiving Neurofunctional Reorganisation according to Padovan (Padovan) and one group receiving Psychomotor Performance Therapy (PPT). The groups were formed according to what therapy the subjects had received earlier. Under a period of ten weeks the subjects received an accelerated program. The dose was raised from one session per week to two sessions per week. The subjects motor and language skills were measured at the beginning and end of this time period with “Motorik test” (MOT 4-6 j.) and “Sprachentwicklungstest” (SETK 3-5j.). The results of the complete tests were evaluated. In MOT 4-6 the dimensions overall coordination, fine motor skills, balance, reactions, takeoff power, movement speed and movement coordination were evaluated. In SETK 3-5 the dimensions language understanding, language production and language memory were evaluated. The data was compared to the norm values of healthy subjects listed in the test-manuals for the total
score and the different dimensions. The results were compared to the findings in literature regarding language and motor development and its dimensions in DS. This comparison was analyzed to explain any discrepancies found or not found in specific areas and which factors influencing the results. A parent questionnaire was designed and used, asking for the most important aspects in the development of the subjects and its influence on the family. Also, the questionnaire asked the parents about the therapies' focuses and their success up until now and what the therapies should focus on in the future, which means what they would like their children still to learn.

16.2.2. Preparations of the study
Parental consent was asked and received for all subjects. The experienced therapists leading the sessions and measurements trained the authors so that the authors were able to participate in sessions and measurements whenever present at the location. Blinded measurements are not advisable as the children might not show their true performance abilities in unfamiliar situations. This concerns especially the connection between the examiner and the child. The therapists/examiners were provided with a form where data of presence, progression and exceptional events were recorded.

16.2.3. Subjects
10 subjects were recruited in the “Praxis fur Krankengymnastik und Sprachtherapie Maria Rodenacker-Wennekers” in Cologne, Germany. Inclusion criteria were diagnosis of Down syndrome, 3;11-6;7 years of age and ability and willingness to participate in the study. All children lived and grew up in families and were not institutionalized at any time. Furthermore they received early interventions all within the first year of life.

16.2.4. Realization of the study
The subjects were measured according to the protocols of the measurement tools in the beginning of the period (t1). The therapy sessions were conducted with the subjects according to the philosophies and strategies of the two different therapies, with the therapists filling out the form concerned with the progression of the therapy. At the end of the time period (t2) all children were evaluated again according to the same protocol as in the beginning, the parents were asked to fill out the parental questionnaire.

16.2.5. Measurements
The “Motorik test 4-6 j.” (MOT 4-6) was used to evaluate the motor skills of the subjects. It is specifically made for children between 4 and 6 years and consists of 18 items. These items test seven dimensions of the motor abilities, such as balance, reactions, movement speed and coordination, takeoff power and fine motor skills. The child can achieve 2 points maximum for each item. To evaluate the language skills the “Sprachentwicklungstest 3-5j.” (SETK 3-5) was used. It consists of different dimensions testing the child’s language understanding, language production and language memory. The different sub tests have different designs depending on the age of the child. The different dimensions are scores separately and no total score is given. Both measurement
tools have been proven to be valid and reliable (Grimm, 2001; Zimmer and Volkamer, 1987).

The measurements were taken by the therapists or by the authors in conjunction with the therapists. The therapists had experience in testing and performed the tests according to the protocols. With this special group of children certain aspects such as a considerable degree of motivation and the creation of a playful situation were necessary.

The total of scored points (RW) and norm values (MQ in MOT 4-6 and TW in SETK 3-5) were calculated and compared for T1 and T2 between the entire population and the separate therapy groups. A MQ of 100 equals the average of RW of healthy children and a TW of 50 also equals the average of healthy children (Grimm, 2001; Zimmer and Volkamer, 1987). The dimensions were analyzed in the same manner. The data was also compared to the norm values of healthy subjects listed in the test-manuals for the total score and the different dimensions. P-value of 0.05 and a two tailed T-Test analysis were used.

The therapists’ notes during the therapy sessions and tests were used to analyze factors influencing the test results and if any subjective progress had been made. The parental questionnaire was used to find any subjective progress from therapy in the above mentioned period. The opinions on the therapies, their influence on the subjects’ development up until T1 and which focus they should have was asked as well.

16.3. Results
The results of MOT 4-6 showed a mean RW of all ten children of 11, 6 (t1 being yellow) and 12, 3 (t2 being green). The mean of the healthy children between the ages of 4-6 years is 20.12 according to the MOT 4-6 (Zimmer, R./Volkamer, M., 1984). The mean age of this presented group lies below this mean age of the norm. Therefore lower scores are to be expected. The SD is 6, 15 RW and is equal to the range between 85 and 115 MQ. It becomes obvious that even though a number of children lie within the SD of healthy children, most scored lower than the SD. The mean MQ is 75,4 at T1 and 79,2 at T2.

<table>
<thead>
<tr>
<th>Subject</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (T1)</td>
<td>4</td>
<td>3:11</td>
<td>5:9</td>
<td>6</td>
<td>3:11</td>
<td>5:6</td>
<td>4:3</td>
<td>5:7</td>
<td>6:7</td>
<td>6:5</td>
</tr>
<tr>
<td>RW (T1)</td>
<td>7</td>
<td>5</td>
<td>15</td>
<td>17</td>
<td>6</td>
<td>7</td>
<td>13</td>
<td>7</td>
<td>11</td>
<td>18</td>
</tr>
<tr>
<td>MQ–Standard (T1)</td>
<td>82</td>
<td>75</td>
<td>80</td>
<td>86</td>
<td>78</td>
<td>55</td>
<td>100</td>
<td>55</td>
<td>58</td>
<td>85</td>
</tr>
<tr>
<td>Subject</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Age (T2)</td>
<td>4:1</td>
<td>3:11</td>
<td>6</td>
<td>6:2</td>
<td>4:1</td>
<td>5:8</td>
<td>4:5</td>
<td>5:9</td>
<td>6:1</td>
<td>6:7</td>
</tr>
<tr>
<td>RW (T2)</td>
<td>9</td>
<td>5</td>
<td>16</td>
<td>20</td>
<td>13</td>
<td>10</td>
<td>14</td>
<td>6</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>MQ–Standard (T2)</td>
<td>88</td>
<td>75</td>
<td>79</td>
<td>91</td>
<td>100</td>
<td>64</td>
<td>103</td>
<td>52</td>
<td>67</td>
<td>73</td>
</tr>
</tbody>
</table>

(Table1 shows all ten children at T1 and T2)
All children improved between 1-7 RW. On average each child improved about 1.7 RW points. A two tailed t-test analysis was used to compare the measurements of T1 to T2 of all ten children. The P value was 0.67. Thus no significant difference was found between t1 and t2. (Table 1)

Most of the ten children portrayed problems particularly in exercises that required balance, takeoff power and movement coordination whereas overall coordination, fine motor skills and movement speed showed to be closer to the norm. (Table 2)

The findings of this study show the same characteristics of the patient group Down syndrome as displayed in literature in section one.

<table>
<thead>
<tr>
<th>Motor dimension (MD)</th>
<th>Norm (mean)</th>
<th>Mean RW (T1)</th>
<th>Mean RW (T2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Overall coordination</td>
<td>6,31</td>
<td>3,4</td>
<td>4</td>
</tr>
<tr>
<td>2. Fine motor skills</td>
<td>4,1</td>
<td>2,9</td>
<td>2,8</td>
</tr>
<tr>
<td>3. Balance</td>
<td>5,82</td>
<td>2,0</td>
<td>2,4</td>
</tr>
<tr>
<td>4. Reactions</td>
<td>2,32</td>
<td>1,2</td>
<td>1,4</td>
</tr>
<tr>
<td>5. Takeoff power</td>
<td>2,78</td>
<td>0,5</td>
<td>0,3</td>
</tr>
<tr>
<td>6. Movement speed</td>
<td>3,31</td>
<td>1,9</td>
<td>2,1</td>
</tr>
<tr>
<td>7. Movement coordination</td>
<td>1,61</td>
<td>0,6</td>
<td>0,8</td>
</tr>
</tbody>
</table>

In table 3 the mean RW of the seven dimensions achieved by the Padovan and Psychomotor group at t1 and at t2 (Table 3) are listed.

To analyze the separate groups’ differences between t1 and t2, a two tailed t test analysis was used. The calculated p-values for Psychomotor and Padovan showed much greater values than the accepted 0.05, thus no significant difference was found.

At T1, minimal differences between the two groups were observable but not significant. At T2 the Psychomotor group had a tendency to score more points than at T1 in the dimensions reactions (4) and movement coordination (7) whereas the Padovan group showed to score more points in movement speed (6). However, no significant difference was found.

<table>
<thead>
<tr>
<th>MD</th>
<th>Psychomotor (T1)</th>
<th>Psychomotor (T2)</th>
<th>Padovan(T1)</th>
<th>Padovan (T2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean RW</td>
<td>Mean RW</td>
<td>Mean RW</td>
<td>Mean RW</td>
</tr>
<tr>
<td>1</td>
<td>3,4</td>
<td>4,2</td>
<td>3,4</td>
<td>3,8</td>
</tr>
<tr>
<td>2</td>
<td>2,8</td>
<td>2,4</td>
<td>3</td>
<td>3,2</td>
</tr>
<tr>
<td>3</td>
<td>1,8</td>
<td>2,6</td>
<td>2,2</td>
<td>2,2</td>
</tr>
<tr>
<td>4</td>
<td>1,2</td>
<td>2</td>
<td>1,2</td>
<td>0,8</td>
</tr>
<tr>
<td>5</td>
<td>0,6</td>
<td>0,4</td>
<td>0,4</td>
<td>0,2</td>
</tr>
<tr>
<td>6</td>
<td>1,6</td>
<td>1,6</td>
<td>2,2</td>
<td>2,6</td>
</tr>
<tr>
<td>7</td>
<td>0,6</td>
<td>1,4</td>
<td>0,6</td>
<td>0,2</td>
</tr>
<tr>
<td>Total mean</td>
<td>9,2</td>
<td>12,6</td>
<td>10,0</td>
<td>12,0</td>
</tr>
</tbody>
</table>
Analysis of the data with the Confidence Interval (0.05) in SETK 3-5j showed that no group differed significantly in t2 compared with t1 in any dimension. In both groups the TW were similar in all dimensions. In the dimensions LP (Language Production) - Semantics, LP-Morphology and Speech memory the groups TW were all 31 (±1). In the dimension LU (Language Understanding) -sentences all groups TW were 40 (±1.2). In comparison with normal subjects with the norm TW 50 (±10) all groups scored well below in the dimensions LP-Semantics, LP-Morphology and Speech memory. In the dimension LU-sentences all groups scored just on the margin of the lower border of the norm value. (Table 4, 5, 6) These findings show the same characteristics of the patient group Down syndrome as displayed in literature in section one.

**Mean entire population**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Mean RW T1</th>
<th>Mean RW T2</th>
<th>Mean TW T1</th>
<th>Mean TW T2</th>
</tr>
</thead>
<tbody>
<tr>
<td>LU- Sentences</td>
<td>9.1</td>
<td>9.1</td>
<td>40.4</td>
<td>40.4</td>
</tr>
<tr>
<td>LP- Semantic</td>
<td>1.11</td>
<td>1.01</td>
<td>31.9</td>
<td>30.2</td>
</tr>
<tr>
<td>LP-Morphology</td>
<td>1.33</td>
<td>1.27</td>
<td>32.5</td>
<td>30.9</td>
</tr>
<tr>
<td>Speech memory</td>
<td>0.44</td>
<td>0.64</td>
<td>30.5</td>
<td>31</td>
</tr>
</tbody>
</table>

Table 4 (LU – Language Understanding) (LP – Language production)

**Mean Padovan group**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Mean RW T1</th>
<th>Mean RW T2</th>
<th>Mean TW T1</th>
<th>Mean TW T2</th>
</tr>
</thead>
<tbody>
<tr>
<td>LU- Sentences</td>
<td>8.8</td>
<td>8.8</td>
<td>38.8</td>
<td>38.8</td>
</tr>
<tr>
<td>LP- Semantic</td>
<td>1.11</td>
<td>1.01</td>
<td>31.9</td>
<td>30.2</td>
</tr>
<tr>
<td>LP-Morphology</td>
<td>1.6</td>
<td>1.52</td>
<td>32.8</td>
<td>31.8</td>
</tr>
<tr>
<td>Speech memory</td>
<td>0.66</td>
<td>0.66</td>
<td>31</td>
<td>31</td>
</tr>
</tbody>
</table>

Table 5 (LU – Language Understanding) (LP – Language Production)

**Mean Psychomotor group**

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Mean RW T1</th>
<th>Mean RW T2</th>
<th>Mean TW T1</th>
<th>Mean TW T2</th>
</tr>
</thead>
<tbody>
<tr>
<td>LU- Sentences</td>
<td>9.4</td>
<td>9.4</td>
<td>41</td>
<td>41</td>
</tr>
<tr>
<td>LP- Semantic</td>
<td>1.11</td>
<td>1.01</td>
<td>31.9</td>
<td>30.2</td>
</tr>
<tr>
<td>LP-Morphology</td>
<td>1.06</td>
<td>1.02</td>
<td>32.2</td>
<td>30</td>
</tr>
<tr>
<td>Speech memory</td>
<td>0.22</td>
<td>0.62</td>
<td>30</td>
<td>31</td>
</tr>
</tbody>
</table>

Table 6 (LU – Language Understanding) (LP – Language Production)

The therapist protocols reported that the children were present and that the sessions were carried through properly. During the testing of language two times it was reported that the hearing could have been affected by an infection. One child was reported to be bilingual. For the motor test one child was reported sick and therefore unable to focus during the test, the test was repeated. Three times the understanding of the tasks and one time the endurance were marked as poor.
The parental questionnaire showed that one parent noticed an obvious improvement within the time period. The majority of the parents have a positive attitude towards the therapies and their benefits. However, they do not solemnly contribute the progress in development to one therapy. Other factors mentioned were additional speech therapy, kindergarten, dancing, gymnastics, and other recreational activities that support the child's development. The most frequent milestones mentioned by the parents were social integration, locomotion, independence and communication. E.g. of sub items in these categories mentioned were; ability to express wishes, pamper independent, ability to dress, attention and concentration.

16.4. Discussion
Both of the hypotheses were answered positively since the results of the statistic tests and qualitative comparison with literature agreed with the argued hypotheses. Still, there were very obvious and less obvious confounding factors. The study’s time period is too short. Mrs. Padovan proposed a time period of two years for the Padovan therapy to show effects. Therefore this study should at least have a length of 1-2 years. During such a study it would be advisable to have repeated measurements to display the progress more closely. The absence of a control group has to be accepted since it is not ethical to deny therapy to a child with the diagnosis of Down syndrome. It is not advisable to use blinded assessors because the children have to be in a comfortable situation when tested. Otherwise the tests will not show their true abilities. Since the individuality in subjects of Down syndrome is great we recommend using as large subject groups as possible in order to be able to generalize the results. The mental age should be taken instead of the chronological age (CA). It says far more about the development of a child with DS than the CA. Further, individuals with DS show great differences in development due to secondary health problems which have a great influence on the child’s developmental progress. All these factors should be taken into consideration when assessing different abilities.

No significant difference was found in either motor or language abilities in the statistical analysis of the MOT 4-6 or SETK 3-5 in the entire group or within both therapy groups. This is most certainly due to the short time period. However if any difference would have been found it would be difficult to contribute it to the therapies alone unless a difference between the therapies would have been found. When comparing the mean (RW) of t2 to the norm values (RW), adjusted to the mental age by using the lowest norm values possible, we found the group to be slightly below the average in MOT 4-6. Again this is an indication to use the mental age as point of reference instead of the chronological age.

Although the MOT 4-6 explicitly states that the different dimensions of motor control cannot be separated from each other, they can still give some indications on where the most profound problems of an individual lie. The analysis of these dimensions can also show if our ten subjects can represent the entire population with DS between the age of 4 and 6 years. If deviations had occurred it had been an indication for further research in those specific dimensions deviating. Especially since all of these children had received either Padovan or Psychomotor from early age on and it should be examined if there are any connections.
We started to look at the items and tried to see if these items really tested the indicated dimensions or if the children failed due to other reasons. What was particularly difficult for all children were parallel, two legged jumps. Therefore the children scored almost always zero points in three items out of five in the balance dimension. They also had difficulties with the movement coordination exercises. The items required a certain degree of concentration and of course coordination. It appeared to be the case that the children either did not understand the goal of the exercise completely because they just repeated the shown movement or they somehow anticipated that this exercise would be challenging and therefore lost concentration quicker than usual. For example, when throwing at a target they did not seem to aim and concentrate sufficiently at the target.

Takeoff power tested strength of the leg and the ability to coordinate this strength. The strength itself was not the most influencing factor although the literature indicates a decreased strength in children with DS. The jump was again the problematic component. It consists of a lot of balance and the coordination of both legs and that is what was most effected the results.

Tapping, rolling, walking through a hoop where those items that were in particular easy and contributed to the good results of the other above mentioned dimensions.

A suggestion would also be that the sequence of the exercises must be thoroughly taken into consideration because these children appeared to show difficulties switching from active exercises that require speed to those which required concentration.

The obvious improvement noticed by one parent can be explained by the increased intensity of the therapy inducing a boost of development in the child. This child was the youngest one of the group.

**16.5. Conclusion**

The aim of this entire project and in particular this pilot study was to prepare for a long term project. The pilot study has shown many aspects to be considered when designing such a study. We therefore suggest the recommendations to be followed and the points of discussion to be carefully considered when doing so.
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