MOTOR LEARNING PRINCIPLES IN THE SERVICE OF MOTOR SPEECH TREATMENT FOR CHILDREN DIAGNOSED WITH AUTISM

ABSTRACT
Motor learning is usually learned in a sport academy. Its main practical purpose is to improve training methods in sport and other areas such as playing music or dancing. The use of motor learning knowledge doesn’t belong to the world of sport but to the world of movement wherever it exists. One of the fascinating areas of movement is speech.

Speech in its basic form is motor based, before being used as a tool for language and communication. It is the most complicated motor task in the human body, since for every syllable production we activate directly and indirectly over 100 muscles in precise timing. Surprisingly, children acquire speech spontaneously, without direct guidance. It happens because the nervous system enables it. Children who can’t acquire speech spontaneously due to deficit in motor planning will need to learn it step by step, until achieving the whole tool. It will require high accuracy, resilience, faith, supporting system and skilled professionals to guide the process. One of the important tools for professionals to use in treatment of speech is the motor learning principles, addressing to the nature of this phenomenon.

This article will focus on the integration and implementation of motor learning principles (MLP) in speech treatment. It will present the way of borrowing ideas from the sport field into speech treatment.

KEYWORDS: Motor learning, speech, treatment, sport

1. INTRODUCTION
The purpose of this paper is to discuss the theoretical and practical use of motor learning principles in speech therapy while treating CAS. The paper strives to borrow idea from the world of sport into the world of speech therapy. In order to discuss this, we need first to understand the motor aspect of speech, and what are the interactions between speech, language and communication domains. Verbal communication is the outcome of these three domains and is one product of three major systems. Distinguishing these concepts is vital for analysing the function of each system separately, however it is not always easy to accomplish.
Communication and social interaction are final goals of this complex system. In order to sustain good interpersonal communication, we can use several tools such as eye contact, nonverbal body language, gestures, the type of clothes we wear, the kind of accessories we use, the type of car we drive and so on. We can use perfume in order to deliver a message while deciding which perfume to put on. However, the best system to deliver a complex, concrete or an abstract message, is the language system. In the inheritance cycle (Christopher Paolini, 2002) the dragon and its rider “speak” through exchanging thoughts (not words), they simply transfer their feelings and ideas. This is a pure way of delivering the full intended message in all its facets. Unfortunately, in reality we are not there yet, hence the need to translate these feelings into a different entity that would be understood by the addressee. We put our thoughts into words in complex structures and express them verbally or by writing/typing. In another words, we use language.

Language is a complex system of concrete and abstract concepts which enables the delivery of messages, learning and thinking in a complex manner. The language is our preferred tool of communicating and learning since it gives us the ability to express complex ideas. The language system “belongs” to the cognitive domain, but some will classify it as a separate system. The two traditional cerebral areas that are responsible for language acquisition and management are Vernica (receptive language) and Broca (Expressive language). Modern theories explain language acquisition and management in more dynamic models (Roy et al. 2006) rather than only two isolated areas in the brain (Chomsky, 1986).

Speech is the motor tool that enables the use of verbal language and communication. Although the final outcome of verbalization goes through the complex avenues of language and the pragmatics of communication, it is basically a motor skill. We shouldn’t confuse the motor aspect of speech with the complex verbalization which includes language and pragmatics.

When verbal communication goes through the typical course of development, we get an outcome which is a complex combination of these systems, the ability to talk. When the outcome is damaged and not at the expected level, it means that some links within the chains of speech, language or communication skills are not working properly. In this case we need to differentiate between the systems and understand where the primary damage is, and which one is secondary or tertiary. If the source of the deficit is motor speech, then we need to address the problem as motor based. In order to do so, we need to refer to speech as a motor entity.

2. SPEECH AS A MOTOR ENTITY

The ability to speak is usually attributed directly to language, but speech is first and foremost a very complex motor ability. Despite this, it is acquired without any direct structured learning. While speaking, there are more than a hundred muscles working simultaneously with very delicate timing and very small amplitudes of movement. Humans can pronounce up to 20-30 phonemes per second which means we can perform 20-30 different motor schemes per second. No other motor system in the human body or other sport activity demands such accuracy (Denes & Pinson, 1993). Let’s analyze speech as a motor entity in order to understand the motor facets of it.
2.1 Analysis of the Consonant /k/ as a Motor Entity

The consonant /k/ is a plosive consonant. The air wave is being blocked completely by the rear third of the tongue and the soft palate. The consonant /k/ is not vocal (no vocal cords involvement). In addition, the velum contracts and blocks the nasopharyngeal passage hence no nasality in the /k/ sound articulation.

2.1.1 Biomechanical Considerations and Primary Muscles:
1. The mouth is open. Participation of the suprahyoid muscles in activating the Temporo-mandibular joint.
2. The lips muscle (Orbicularis oris) doesn’t contract.
3. The back of the tongue rises (Glossopalatinus muscle) until it touches the soft palate. This is an internal control parameter of /k/ articulation which is the most unique and important factor.
4. The front of the tongue lies lower in the oral cavity.
5. The exhaling muscles (abdominals, inter-costalis) press the air out of the vocal/air tract and create an air pressure where the tongue touches the soft palate.
6. The vocal cords spread apart by the posterior cricoarytenoid muscles.
7. The Pharingopalatinus muscle shuts off the naso-pharynx passage and doesn’t allow passage of air out of the nose.
8. The Glossopalatinus muscle relaxes quickly and a burst of air comes out of the mouth. The sound created is /k/.

2.1.2 General Biomechanics
The neck muscles and the infra hyoid muscles act for dynamic stabilization. They give a proximal stabilization to the distal muscle contraction. The abdominal muscles are the first to contract out of all the muscles that are involved in this motor task, in order to supply the basic core stabilization to support any further movement.

2.1.3 Mobility vs Stability
A regular motor task usually has a clear definition of mobility or stability. The question is simple: is the base of support (BOS) in motion or not? A speech motor task is more complicated to analyze. The BOS definition is not clear. Do the legs act as BOS? Or perhaps it is the head balance/control? As mentioned earlier, the neck muscles give a proximal dynamic stabilization to the articulators. This has been demonstrated clearly among patients with Apraxia of speech (AOS). Phenomenon of head tremor while trying to speak can be seen clinically. The tremor will occur only when the patient will try to pronounce a difficult syllable and will stop when the patient stops trying. Clinically, giving gentle support to the head will usually help the patient to pronounce sounds better. When analyzing the mobility questions regarding all the syllables, we must consider the status of the neck control as our reference. The speech motor task can be performed in either the stability or mobility status and it is determined by the neck activity. A stability situation can be standing, sitting, lying or swinging in a hammock while the head is supported. A mobility situation can be walking, running swinging on a swing without head support or talking while moving the head from side to side. The movement control in mobility condition is more difficult.
2.1.4 Discreet vs Continuous Movement
Pronouncing /k/ is a discreet movement. It is a very short movement with a clear beginning and end. A discreet movement is related to ideomotor planning (Melcher et al. 2013) which involves automatic responses and activities of more automatic systems. That in comparison to ideational planning which is related to complex sequencing of movements that involves more consciousness planning.

2.1.5 Open vs Closed Movement
Pronouncing /k/ is a closed motor task since the task performance time is measured in milliseconds; there is no room for environmental interference or variability of the task. There is a specific way this task should be performed with little place for variations.

2.1.6 High vs Low Attention Demand
High vs Low Attention characteristics of a motor task analysis is defined by taking average person abilities as a reference. For example, a sitting task doesn’t demand much attention while running on a treadmill does. But what if the sitting task is performed by an 80-year-old lady who is recovering from a stroke? Then it might require a lot of attention. Pronouncing /k/ doesn’t require attention from the people who can speak, but it can be an exhausting, attention demanding task for a child who can’t pronounce it.

2.1.7 Auditory Perception
Learning pronunciation is done primarily through the auditory tract (hearing and auditory perception). Unlike gross motor movement, we usually can’t see the speech motor movements being learned. Learning occurs by trial and error in reference to auditory perception. Thus, auditory perception has a crucial role in speech acquisition. When we hear the sound /k/ we can try to find a way to produce the same sound using our articulators. We try different motor paths until we hear ourselves producing something similar. The next learning phase will deal with shaping the motor action until the sound that comes out, sounds similar to the one we tried to imitate. At this point, the motor scheme of the /k/ production will be conditioned to the auditory perception of the sound /k/.

2.1.8 Somatosensory Input
The somatosensory input, just like the auditory perception, is also relevant to speech motor planning. The somatosensory input includes tactile and proprioceptive information. The tactile information is relevant for the awareness of the articulators. If one doesn’t have accurate feeling of the tongue’s position and movement, it might affect learning pronunciation /k/ consonant.

2.1.9 Motor Environmental Constraints for Learning
Learning how to pronounce is an implicit process, effected by environmental constraints:
- Regulatory conditions - body position can influence the production of the consonant /k/. Lying on the back or tilting the head 110 degrees backwards causes the dorsal part of the tongue to move passively by gravity towards the soft palate, where the consonant /k/ is performed.
• Non-regulatory conditions- the child hears the language and tries to imitate what he/she hears. Some of the consonants can have visual input on top of the auditory input (bilabial consonants such as /b/ /p/ /m/). The pronunciation of the consonant /k/ is learnt only by the auditory channel and via pronunciation trial and error. Background noise can interfere with imitation of the consonant /k/ since the child relies only on the auditory input.

• Context - imitation of the sound /k/ out of context might not elicit motivation for practicing for a child that has normal cognitive abilities. If the child is motivated, he/she will try practicing more and have more opportunities to learn the sound.

This analysis of articulating the consonant /k/ and some of the specific learning requirements shows the complexity of the process. It has many facets as a motor entity while being only a single elementary element in verbal communication – a phoneme.

3. CHILDHOOD APRAXIA OF SPEECH (CAS)

Childhood Apraxia of Speech is one of the possible causes for a non-verbal condition in childhood. The nature of CAS wasn’t clear amongst professionals, debating between phonological or motor origin. In 2007 the American Speech and Hearing Association (ASHA) declared that CAS is of motor origin. ASHA’s definition of CAS summarized to “Childhood apraxia of speech (CAS) is a neurological childhood (pediatric) speech sound disorder in which the precision and consistency of movements underlying speech are impaired in the absence of neuromuscular deficits (e.g., abnormal reflexes, abnormal tone).

CAS may occur as a result of known neurological impairment, in association with complex neurobehavioral disorders of known or unknown origin, or as an idiopathic neurogenic speech sound disorder. The core impairment in planning and/or programming spatiotemporal parameters of movement sequences, results in errors in speech sound production and prosody”.

A clinical definition, according to the VML method (Vashdi, 2013), is “Total or partial deficit of intended and deliberate pronunciation of a phoneme, syllable or a word, due to deficit in sensory input and/or deficit in motor planning and, in the absence of paralysis, hypotonia or misunderstanding of the verbal task.” This type of definition helps to understand whether the non-verbal condition is motor based or not.

The prevalence of CAS is unknown. A few estimates were published; however they are not accurate enough (Delaney & Kent, 2004, Shriberg, Aram, & Kwiatkowski, 1997). The latest research examined the occurrence of CAS within Autism and found that 63.6% of children diagnosed with autism had CAS as well (Tierney et al. 2015). If the Autism rate was 1:68 in 2014 in the US (Ramsey et al. 2016), then CAS prevalence would be 1:106 and that is only a subgroup within Autism.

3.1 General Apraxia Characteristics

3.1.1 Affects voluntary movements more than spontaneous or automatic movements
3.1.2 Movement sequencing is easier when manipulating a real object vs pantomiming.
3.1.3 Completing a movement sequence is easier when given a gestural command (imitation) vs a verbal instruction.
3.1.4 Movement sequences will be inconsistent.
4. MOTOR LEARNING PRINCIPLES (MLP) AND SPEECH TREATMENT

Motor learning and control is a scientific field of knowledge which targets mapping the learning procedures of human movements and understanding the patterns of developing these movements. Theoretical models of motor learning try to explain the acquisition of new motor patterns through different stages or mechanisms. In the next section we will discuss few MLP while presenting a theoretical basis alongside speech movement analysis and examples.

4.1 Stages of Motor Learning

Learning a new motor scheme or skill is a process that usually goes through the three stages of learning (Rose and Christina, 2006):

4.1.1 Acquisition – first stage of getting to know the novel task components.
4.1.2 Retention – the ability to maintain task performance after a period of time under specific conditions.
4.1.3 Transfer - the ability to perform the task in different settings and conditions.

In research we use the stages of motor learning to examine change in performance. The first test is a retention test while the more advanced one is the transfer test. Sometimes during the performance and acquisition phase, one condition is superior to the other. In the retention test, the results can be the opposite. The definition of learning is a constant change in behavior. Retention tests show profound changes in behavior in comparison to performance tests since the change in behavior lasts longer. Transfer test results demonstrate superior control in comparison to retention tests since the level of control demanded is higher. The transfer phase has a variety of applicable ways. A task can be manipulated in a variety of ways while these alterations compose the transfer phase. The more control over alterations, the more control over the basic task and the more profound the learning is. For this reason, the transfer test represents higher control over a task.

4.1.1 Top Spin Shot in Tennis

In the acquisition phase the novice learner will learn the position of the legs and trunk, the starting point of the hand movement, the pattern of movement in terms of direction, acceleration, range, deceleration, speed, type of grip, eye hand coordination and more. Each part will be practiced with its own emphasis.

In this retention phase we would like to have an accurate top spin shot in training (as being practiced). The player will need to produce this shot accurately in the training, between days and weeks.

In the transfer phase we would like to see control over the top spin shot under different conditions: different angles, different surfaces, coming as a response to different shots or in a match. The ability to control the same skill under a variety of conditions, shows the strength of the skill and the amount of control. The more controlled movement variations there are, the more control will we have over the specific movement.

4.1.2 Speech and Motor Learning Stages

Example - imitating the word /table/.
• Acquisition phase – learning how to pronounce /t/, /b/, /ta/ /L/ and then to put them together into the word /table/.
• Retention Phase – being able to imitate the word a few times in the same treatment session and after one week under the same conditions.
• Transfer phase – imitating the word in different places with different people, using the word in communication cycle or using the word with different intonations and speed.

We can analyze every speech motor task learning through the stages of motor learning. When judging the level of motor control, we need to understand at which stage the learner is, the course of progress, and future transfer pathways. These aspects will affect the decision of how to intervene.

4.2 Specificity vs Variability of Training

Specificity of practice - The principle specificity of training is defined as practicing a specific task as similar as possible to the required movement in the real-world conditions. According to this principle, practicing a task under specific conditions will bring better control over that task. When imitating the real-world conditions of the task, the learner is practicing the same movement patterns, cognitive processes and environmental constraints which eventually will result with better performance. The theory emerged from the work of Thorendike and Woodworth (1901) and was called “the theory of identical elements”. It claimed that transfer learning will be enhanced if the learning will contain identical elements as real-world conditions. This principle was borrowed into the specific motor learning field (Barnett, Ross, Schmidt and Todd, 1973). Kicking a penalty kick in soccer under pressure of finals with 80000 people screaming in the background is a motor task being performed under very specific emotional, cognitive and environmental conditions. Muscle fatigue, type of goal keeper, surface conditions can add the specificity of this motor task. It is not similar to practicing a penalty kick under sterile conditions.

Variability of practice - Schmidt’s scheme theory (1975) postulated that practicing a skill in different ways will help the learner to set the rules for that type of movement and enhance learning. Rather than throwing the ball to the basket from a specific spot the learner should do it from different spots, use different ball sizes and weights. Several studies supported this theory showing improved transfer of skill in comparison to specific training. This type of training can support generalization of a skill in real-life events. The everyday tasks in real life are complex and variable. They take different shapes and performed slightly differently each time. Using the key to open the house door will be done once while holding a little child in the other hand, next time in the dark and third time while having coffee. Each time performing the same task under different constraints. The environmental demands and constraints are dynamic and can not necessarily be anticipated; hence training can’t be specific in many cases. It can’t anticipate and copy the real-world conditions. Practicing in a variable way can prepare the learner to the unexpected dynamic constraints of the real-world.

Research show that variable practice of a task brings to better performance of a similar new task (Rose and Christina, 2006). Both practicing strategies have advantages and downsides. Using each as needed in the right balance will be the accurate way for having the most effective practice. For unique consistent tasks in which there is not much variability
in performance such as diving from a platform or bowling, a specific training would be very beneficial. For a dynamic, unpredicted system we might like to use more of variable practice.

In addition, variable learning can be significant and profound since the learning is not focused only on what is true, but rather on what is “wrong.” In learning, knowing what is correct is also knowing what is not correct. The more the learner understands what is not correct regarding a specific task, the correct answer is being “more correct.” An entity has more meaning when it’s not something else. For example, when a child learns the concept /ball/ it is connected to any round object that can be thrown or played with. Basketball is a unique ball, which becomes more unique after understanding that it is not a soccer ball, not a volley ball, not a hand ball, and not a beach ball. The more distinguishing features a ball has, the more unique it becomes. The same principle works in navigation. Navigating to a final destination requires knowledge of the best route to get there and apparently it is enough. However, this pattern of thinking makes use of the minimal amount of knowledge required for solving the problem (navigating to the final destination). In the case of unpredictable constraints such as traffic, road blocks, weather conditions or unpredictable tasks on the way, the driver will not have enough knowledge to solve the problem (plan an alternative route,) and that is due to lack of information. It is not enough to know what the single best temporary solution is, but rather what the other options are as well. Not just what it is but also what it is not. The navigation system in the car will find the best route and guide the driver, but it is flexible to change routes or offer other alternatives since it contains many options. A soldier in an elite unit which needs to navigate his way to the target, must have a mental map of the area with as many features as possible. Then he will be able to adjust if needed, and recalculate the navigation pattern from any landmark within the area.

4.2.1 Speech and Specificity/Variability of Practice

How does specificity or variability of practice influence speech motor treatment? Specificity can be manifested in two ways; imitating real-world conditions or repeating the specific motor pattern. Practicing at the word level in conversation condition will be the real-world condition (say ball/ baby/ table etc.). This type of training is common since it is pragmatic based and serves language and communication needs which are the reason for practicing speech in the first place. However, the word level (combination of few consonants or syllables) is high on the motor hierarchy of speech, thus practicing that requires usually good control over its basic elements, consonants, vowels and syllables. So, practicing specifically at the word level can be beneficial if there is good motor control over fundamental structures. In addition, real-world conditions for verbal communication requires other skills such as word retrieving, syntax, basic communication skills, intention or adequate processing speed. Hence, the specific practice encompasses much more than the motor aspect of speech and that should be considered when deciding to choose this form of practice. It might create too many degrees of freedom for the learner to deal with.

The other specificity form of motor speech training is the single syllable level. This practice contains the repetition of the targeted single syllable based on the assumption that repeating the same syllable will improve the motor control. There is good support in the literature for specific practice of a discrete skill such as single syllable articulation (Reilly, Morris & Whyte, 2009).
On the other hand, we should consider the benefits of variable practice in motor speech training. Practicing a single syllable such as /pi/ specifically will include repetitions of this syllable only in its basic form or within a word usually as the opening syllable. However, practicing /p/ with other vowels can contribute to the control of /pi/ as well. When practicing only /pi/ the learner learns what /pi/ is. When practicing /po/, /pa/, /pu/, /pe/ the learner keeps a similar motor scheme (keeping the same consonant) but creates a change which teaches not only what /pi/ is but rather what it is not in the inner circle. The knowledge of what “it is” not strengthen the power of the target syllable.

Another aspect of variability of practice can be observed at the words level. When the learner is required to put two or more consonants in the same utterance such as /mummy/, /apple/, /movie/, or /car/, a transition skill between syllables is required. The skill is first structure dependent and not just specific word based. Hence in order to improve the articulation of a word such as /movie/ (CVCV structure), practicing specifically the word /movie/ is a good strategy, however practicing the CVCV structure in general through other combinations will support gaining the word /movie/ and any other two open syllabic combination.

Practicing a single syllable such as /di/ solely is the pure way of specific training. Practicing it at the beginning, middle or end of different words can be considered specific training since it is imitating the real-world needs. On the other hand, can also be considered as variable practice since the requirements in articulating the syllable is changing due to change in meaning, emotional state (possible effect of the words meaning), different transitions and different segmental positions.

Each strategy, whether variable or specific training, is beneficial in speech training depends on the needs of the learner, learning style and skill. The therapists should be aware of the best strategy to use temporarily and flexible enough to move in between strategies when needed.

4.3 Part Task Practice vs Whole Task Practice

Whole task practice refers to a practice in which the task is being practiced as a whole. Part task practice refers to a task which is divided into parts to be practiced separately. Like bottom up vs top down principles, the partial task vs whole task practice holds two ends of the stick. It is a question of whether to attend to the skill from its parts or rather practice it as a whole. Research findings suggest both ways can be effective depending on a few factors such as skill complexity, capabilities of the learner, and organization of movement. A condition of high task complexity and low organization of movement will favor using the partial task practice (as well as novice performer who has little or no knowledge of the task). However, lower the complexity of the task is and the more expert the learner is, the tendency would be for whole task practice.

High complexity movements can include dance, gymnastic floor routine, basketball attacking maneuvers or driving. High complexity movement involves sequences of small movements which together enable the complex outcome of the movement. These movements are not necessarily related temporally; hence they are very dynamic, so it is hard to perceive them as whole. Therefore, it is easier to divide the complex skill into fragments and master each separately and then tie them together.
A novice learner has limited knowledge in learning processes and specifically regarding the complex task, since the learning skills are not matured hence demands more effort in learning a new skill. Therefore, in a case of a complex skill it would be easier for a novice learner to do part task practice rather than whole task practice. A high complexity task in relation to the learner’s expertise is somewhat subjective. A task that would be easy for an expert learner might be considered complex for a novice one.

Fabiani et al. (1989) compared two-part task strategies with whole task practice of a complex computer game task. The part task strategies were superior to the whole task strategy. Within the part task strategies, the hierarchical one was superior to the integrative one. When practiced each part separately better results were achieved in comparison to emphasizing elements within the whole game.

Park, Wilde & Shea (2004) found that Part-whole practice was more beneficial than whole practice for a 16-element movement component on the transfer test. The Part-Whole practice consisted of dividing the task into two sections of 8 and 8. Most of the research protocols regarding part and whole task examine simple tasks such as tapping or controlling a computer joystick. That cannot be compared nor reflect on high complexity motor tasks such as playing table tennis, dancing or water-polo, since the demands of these tasks are much higher in all aspects. We should be considering the limits of the research in applying the guidelines to actual training.

4.3.1 Part Task Practice Strategies

- Segmentation – practicing parts of the task and then bringing them together after mastering each part. For example – a table tennis game. A whole task practice would be playing the game. However, the game includes different type of shots and strategies. Segmentation of the table tennis game skills would be practicing separately backhand, top spin, forehand, blocks, accuracy on the table, slice, slice from a top spin, serving etc. In order to master each segment of the game it is necessary to practice each separately.

- Simplification – various aspects of the skill or environment are simplified. In time, the practice becomes more complex until it gets to its desired level of performance. For example – a table tennis game. Ways to simplify the practice would be using a better controlled racket, practicing with novice competitors, using a larger table practicing with a robot using the slow pace, using the best environmental conditions etc.

- Fractionization – two or more components of the skill that are normally performed simultaneously are practiced in isolation. For example – driving – focusing each time different aspects such as gear shift, looking at mirrors, parking, turning, reacting to dangerous hazards, reading road signs while driving etc. It resembles working through reducing degrees of freedom. When the novice driver controls each part he can combine driving on a busy main road, needing to read the road signs, reacting to motorcycles passing with no warning or traffic light changes to red without enough notice. In this situation the driver needs to consider all of the above simultaneously and act accordingly.
In speech we can find many low amplitude movements in each speech sound. Some of these movements are sequenced temporarily and some simultaneously. A simple word such as /banana/ is a complex motor task for a child with CAS. The use of part task practice is a necessity in the training/learning procedure along with whole practice.

4.3.2 Speech Part Task Practice Strategies
Segmentation is a basic foundation of speech treatment. Each phoneme is a segment hence practicing CV combination such as /ma/ can start in practicing /m/ and /a/ separately. When there is a good control over the segments, we can put them together. Typically, speech development is being acquired in a whole practice implicit way, however, in the case of CAS when whole practice is not beneficial then the segmented part practice should take the primary place. The segmentation takes place for CV combinations (consonant + vowel) or different word structures (CVC, CVCV, CCVC, CVCVC). The therapist will practice the segments separately and then form the desired structure from them.

The simplification principle is applied mostly at the word level. Complex words can be simplified into less complex structures, however still be useful pragmatically while fulfilling the motor speech demands of the training. For example, if the targeted word structure is CVCV, a word such as /monkey/ (which is CVCCV) can be simplified into /mokey/. In this way the child can use the word but still practice the adequate motor level. If the demand was /monkey/ the child wouldn’t be able to accomplish it since there were too many degrees of freedom. Having a CVC structure at the beginning of the word is too difficult at this stage. Through simplifying we can enable the practice of more words in the targeted level.

Fractionization can be practiced on several occasions, for example in problems of soft palate insufficiency. Most of the consonants aren’t nasal hence there is a need for the velopharyngeal closure. This contraction of the soft palate is being done while articulating the consonant. In case of soft palate insufficiency, we can train the velar movement separately from the articulated consonant to get better control over that specific pattern. Another example is articulating /L/. The control parameters for the /L/ consonant are jaw opening and placement of the tongue at the alveolar ridge. Adding to these parameters, sided air stream with vocal cord activity at the same time, will produce the consonant /L/. For children diagnosed with CAS it is sometimes difficult to control the opposite jaw and tongue movements (one goes down while the other goes up) in addition to the forced air stream and vocal cords activity. Working on parallel fractions would be practicing the jaw opening and upward tongue movement without the sound production. When each part is mastered then it can be placed together simultaneously.

5. IMPLEMENTING MLP IN SPEECH THERAPY
The VML method is a treatment tool designed specially to treat motor speech deficit via motor tools. The method borrows motor learning principles and other motor training tools in order to answer motor deficits in speech. The method was developed through intuitive clinical experiences with children diagnosed with CAS since 1996. The intuitive experience grew and developed over the years and became a system designed to treat CAS. This system has two complementarian sides; the algorithm level/organized side, and the dynamic/flexible side.
5.1 The VML method structure involves:
5.1.1 A multi-dimensional speech evaluation using a specific evaluation form and protocol.
5.1.2 A multi-dimensional analysis of the child's developmental condition using a specific analysis form;
5.1.3 Identifying the key objectives for speech treatment and the formation of a treatment plan with a specific treatment plan form.
5.1.4 The use of over a hundred Manual techniques in treatment.
5.1.5 Applying motor learning principles at various levels and aspects of the method. The VML makes use of the motor learning principles shown here in many aspects of the treatment.
5.1.6 Applying unique teaching principles which enable practicing manual techniques and other treatment tools.

5.2 The VML method dynamic side of the system enables adaptation of the system to the specific needs of the child and includes:
5.2.2 Treatment objectives are determined based on need and not according to a set program.
5.2.3 Techniques – there are several techniques per treatment topic. The system welcomes new techniques.
5.2.4 Type of therapist – variety of professional can use the method alongside family members and tutors.
5.2.5 Place of therapy – therapy can take place in variety of places according to the program needs and success of the session.
5.2.6 Amount of sessions during the week and their length are varied according to need.
5.2.7 Different weights for every objective based on dynamic needs.
5.2.8 Adaptation of the system to the cultural preferences of the child.
5.2.9 Adaptation of the system to the cognitive, lingual and communication needs of the child.

The method uses motor learning principles while considering CAS as a motor planning-oriented problem. Nevertheless, language and communication goals have a major weight in the evaluation, analysis and the treatment plan. In addition, each vowel, consonant, syllable and word have special techniques that assist the child in learning to imitate the desired sound. The VML strives to create a treatment system on a weekly cycle rather than having a traditional weekly treatment of 45 minutes. The treatment system strives to have a daily practice and to find structured and monitored ways to implement the practice in everyday life.

The basis of the method requires (or allows) questioning the treatment procedure and decision making on a regular basis. No technique or assumption is free of criticism and re-evaluation of the axiom professional perception is it’s the basic concept. This way of thinking regarding the treatment procedure, enables the method to change rapidly based on new data and better understanding of the broad picture.

In some way, practicing the method resembles training in sport. The way the treatment program is composed is similar to a training program in sport. The field of intervention and the objectives of the process are very different, however, the similarity of the process encourage borrowing ideas and implementing them in the different fields.
While originally developed in Hebrew, The VML method is currently practiced in various languages around the world.

6. CONCLUSIONS
Applying Motor Learning Principles in speech treatment is fairly new contribution in the field of speech treatment. The PROMPT method was developed in the early 1980’s and focused on tactile cueing as a motor approach and solution to apraxia of speech. However, only in 2007 the American Association of speech and Language pathology recognised CAS as a motor-based deficit and recommended the adequate treatments. Despite this, the professional field hasn’t changed dramatically towards the hands-on or motor practice. It is probably because it takes many years to change the professional perception regarding treatment.

Another professional tendency in recent years is to use assistive technology for communication such as advanced apps for computer or tablet. The fast increase in advanced technology and the decrease in cost, make it more appealing with quick results in comparison to working on motor speech. Therefore, the intervention and knowledge regarding the treating of motor speech deficits is fairly limited.

The use of motor learning principles speech treatment is a necessity which brings new depth into treatment and opens new horizon. It draws a new picture of the deficit from which the therapist can elicit more accurate targets and perform better. It enables the therapist to better explain phenomena within the CAS and to deal with them successfully. This proximity between sport science and speech treatment science and practice is not easily observed. The article bridges the gaps and shows through few examples the interaction between these fields. Practitioners in the field of speech treatment can benefit greatly by implementing the MLP in their clinical practice.

The VML method is presented as a system that uses these motor learning principles as the major and central part of the system. The MLP influence the evaluation, analysis process, treatment planning and intervention in the VML method, therefore setting a unique way of intervention.

REFERENCES


Vashdi, E. (2014). The influence of Initial Phoneme Cue technique according to the VML method on word formation with a child who has apraxia of speech and autism - A case study. International Journal Child Health Human Development. 7(2): 197-203.


