The PROMPT System

Therapeutic Intervention Hierarchy

-A Systems Approach-
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THE PROMPT SYSTEM
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- A SYSTEMS APPROACH -

The PROMPT SYSTEM (Prompts for Restructuring Oral Muscular Phonetic Targets), was first described in a seminal chapter, The Prompt System: Theoretical Framework and Applications for Developmental Apraxia of Speech by Chumpelik (Hayden) in 1981. The system was described as one which uses tactile cues of pressure, place and timing to promote and enhance effective neuro-muscular innervation and coordination for the learning and integration of motor-speech behaviours. The original chapter outlined the parameters for all vowels and consonants and briefly described how the Prompt system could be utilized to provide either an entire template or partial input, for the establishment of phoneme, word or phrase productions.

The current chapter will further detail the intervention hierarchies and strategies, as well as the underlying principles involved for a PROMPT intervention. Further, the underlying framework that is the basis for PROMPT will be described. Specific information on the actual Prompt's themselves, may be obtained from the original article (Chumpelik, 1980) or subsequent ones (Square-Storer, Hayden, 1989).

The goal of this chapter is to help the clinician working with speech-motor control and transition issues begin to come to terms with the levels and interaction of the child's entire motor-speech system. When all parts, as well as the whole, can be seen simultaneously, the clinician will have great insight into the nature of the child's difficulties. It is then that the clinician will be able to intervene in the most appropriate way and at the most appropriate level. Most speech-language pathologists have not been trained to recognize the interactions between the linguistic and motor-speech production process and often begin therapy at too high a level without all the necessary precursors in place. This often promotes frustration for the both the child and clinician when dealing with complex motor-speech issues.
The principles outlined in this chapter may also be used with other systems of treatment. The important premises outlined here are ones that combine our most recent knowledge of speech-motor control systems (Abbs, 1988, Welsmer, 1988) and practical information and levels that should be considered when working with children with speech production difficulties.

Children with any speech production issues, e.g. phonology, dysarthria or apraxia or combinations thereof will may benefit from understanding the PROMPT SYSTEM and principles of the PROMPT SYSTEM and the therapeutic intervention approach. For example, if we consider phonological disorders to be linguistic in their development, all phonemes are ultimately translated into motor movements. Due to a phonological disability a child may produce speech incorrectly. The incorrect motor pattern will become habituated or "rutted" in and thus resistant to change. A motor intervention to change the pattern or production is often the most effective intervention. Other minor speech production difficulties, or so called "functional articulation errors, e.g. /s/,/r/,/l/,/th/, may also be extremely resistant to change. While these sounds may be perceived to be produced "almost" correctly, in isolation, production frequently breaks down at the word or phrase level due to inappropriate muscle bias in connected speech. The speech-language clinician must recognize how the entire motor-speech mechanism from pre-tuning, pre-posturing, posturing and 'transitionalization' works in order to change the production thus, the recognition of the appropriate stage(s) of the speech process which requires intervention must be developed.

The following sections will briefly outline the basic tenants of the PROMPT SYSTEM for both the clinician and child, and present a point-by-point breakdown of all the various levels or stages that must be considered in the intervention hierarchy. The clinician may choose to read each section separately or the chapter as a whole. The final summary checklist at the end of this chapter, when used in conjunction with a particular child, may also assist the clinician in deciding where to begin intervention and what sub-steps the child may or may not have it in place, and at each level.
Therapeutic Intervention Hierarchy

BASIC PRINCIPLES OF TREATMENT

Basic principles of the PROMPT SYSTEM can be subdivided into two categories: (1) principles of clinician behavior; (2) principles guiding the behavior of the client. Each is discussed below.

Clinician Principles

Appraisal

- The clinician must evaluate the child’s entire system; body tone, breath support, phonation abilities, and oral-motor capacity, as well as cognitive and linguistic domains before determining the appropriate levels and intervention strategies. This evaluation may need the input of several other professionals such as it is critical to the understanding of the entire motor-speech and language prognosis.

Knowledge of Motor Control

- The clinician must understand how all motoric variables such as planes of movement and transitions between movements interact. The addition of variables or an increase in difficulty of the interaction may break down the entire speech sequence.

- The achievement of normal movement, (symmetrical and to the mid-line of the face) in both function and appearance is stressed.

Knowledge of Treatment Hierarchies

- All intervention programs should be built on small step progression and while stressing motor-control theory and principles must, as soon as possible, incorporate functional and interactional language use.

- At lower levels of Intervention planning the incorporation of only one variable/change at a time is strongly recommended.
Stabilization

- New variables (phonemes or changes that require the addition of new movement sequences or transitions) should be asked for only when previous variables are stabilized. The Prompt clinician, however, may introduce new or different patterns to the child by "mapping in" the sequence without any expectation for the child to attempt the production.

Normalized Muscle Movement

- Clinicians must continuously analyze the interactions among the subsystems and what existing (normalized) muscle movement the child has to get the most productive use of speech production.

Motor Skills as One Component of Communication

- The clinician is reminded that when dealing with a child, intervention procedures and behavioral, cognitive, social and neuromotor domains must be considered when planning activities around PROMPT Therapeutic Intervention Hierarchies. Care must always be given to the communication process and to the interaction between the child and clinician.

- In children, with minimal verbal or incorrect target production, phonemes as well as "key" functional words and phrases should be taught (programmed). Stress should be placed on establishing control at lower levels, i.e., phoneme control and transition, where accuracy should be maintained. Prompted functional words or phrases not requiring the child's response should be used to guide the child's organization of where/how the target phoneme "fits" within the larger dynamic whole. This procedure emphasises both a bottom up/top down approach and ultimately gives the child "maps" of units that also include timing and transition cues.
Client Principles

Intervention Based On Motor Principles

○ The acquisition of articulation along normal developmental hierarchies or phonological trends are not necessarily adhered to. In most cases, motor-control development will take precedent even in developmental apraxia where basic functions appear intact.

Neuromuscular Intervention and Systems Development

○ As the child’s neuromotor system is stimulated, during PROMPT treatment, and control at lower levels is established, more muscle interaction at higher levels will be seen. The child’s system will do more work and the clinician less.

Individual Differences

○ Depending on facial structure, muscle size and strength, neurological interaction and previously learned patterns, every child will use slightly different muscle movement to reach target positions.

Control, Flexibility and Precision

○ The independent, flexible and coordinated use of all articulators, ie. jaw from tongue, lips from jaw, independent lip control etc. is paramount for efficient speech production and must be the ultimate goal for all clients, to the level of their neuromuscular ability.
THE PROMPT SYSTEM

INTERVENTION HIERARCHY

The following section outlines seven stages in the intervention process. Each stage is interdependent on the one before it and interacts with all of those above. Each stage will be considered within the context of the entire system, however the importance of acquiring voluntary motor control of each subsystem will be stressed. In a treatment protocol, the clinician should be aware of the child's level of control of each stage in order to determine at what place intervention should be focused. Because the system is interrelated the clinician will not only focus intervention at that level but will strive to build the intervention around facilitation of the "weakest" link and attempt to integrate all subsequent levels into the process. A brief outline of the stages is presented below.

STAGE I  General Body Tone for Movement Control
STAGE II  Supportive Speech Function: Breath & Phonation & Voice
STAGE III Single Movement to Combined Movement on a Single Plane: Voice & Jaw
STAGE IV  Adding Additional Planes of Movement
   a.  Voice & Jaw & Facial Contraction
   b.  Voice & Jaw & Facial Contraction & Rounding
STAGE V  Sequential Control of Facial and Oral Movement
   Voice & Jaw & Facial Contraction & Rounding & Tongue Control
STAGE VI  Sequenced Movement on Multiple Planes
   Voice & Jaw & Facial Contraction & Rounding & Tongue Control & Timing
STAGE VII Intonation, Stress, Juncture, and Speech Rate in Sequenced Motor Plans
   Voice & Jaw & Facial Contraction & Rounding & Tongue Control & Timing & Prosody
THE PROMPT SYSTEM

STAGES OF THE INTERVENTION PROCESS

The underlying tenants of the PROMPT system can be found in a systems approach to the organization and interaction of the neuro-anatomical subsystems that support speech. Understanding the function of each system and its relationship to other systems, as well as the interplay between them, is critical to both assessment and the level at which intervention will be successful. If the clinician is not able to determine at which level the child’s support subsystems are either non-functioning, partially functioning, weak or over functioning, they will not be able to establish the type or amount of intervention needed.

The speech system is supported by many different neurophysiological interactions. Although these interactions are not completely linear there is a “groundwork” that must be in place in order to sustain the complex, flexible, movement sequences for speech. This “groundwork” means that each successive stage is dependent on the next to provide support for it’s involvement. It also means that the ability to initiate voluntary control at each level will help to establish the independence for the later stages of well integrated, coordinated, control.

To determine where the speech-motor system is breaking down or what parts are inhibiting the release and function of other parts, a systematic examination must be undertaken. This examination must consider structural (skeletal) frameworks, muscular and neurological frameworks and the interaction among them. Once the clinician understands these systems and their interactions they may begin to decide if the systems can be trained, strengthened or released or whether compensation of one system must be utilized to maximize what other systems lack. The clinician will also then realize that compensation by one system, although helping the child to achieve speech, will always limit the capacity of the entire system and mean reduction of either flexibility, coordination or support of systems at a higher level.

In the following section the Intervention Hierarchy will be presented. It is intended that the clinician recognize these subsystems and their supportive and necessary role to the other subsystems and the interactions among them. The skeletal system and gross neurological systems will not be mentioned here;
although it is expected that each clinician will have thoroughly examined the cranio-facial structure, symmetry, mandibular bite relationships and relationship of the muscular system to these, (i.e. relationship of tongue position to dental occlusion and function). Each section will provide information on how each system relates to other systems, areas to examine and at what level intervention should be considered.

The reader is strongly urged to consider each subsystem with respect to it’s integration with the entire speech system and to structure intervention so as to guide the child in progressive, but functional, steps in the communication process.

**Stage I - General Body Tone for Movement Transition**

The ability of the body to support its self against gravity and perform movements with other muscle groups smoothly and in a coordinated fashion is dependent on the tone within each muscle group. Physiologically, this area is controlled by the basal ganglia and the reticular activating systems as well as the lower brain stem region (Love, 1992). Either too much tone (hypertonicity) or too little tone (hypotonicity) will cause difficulties within the speech support systems. The base support, of all further systems, is laid by the tonal quality of the neurological system as it innervates the muscles. Therefore, it is critical that this system be evaluated. In a child with dysarthria, some level of tonal disturbance will be seen. In a child with “pure” developmental apraxia of speech or phonological disorder tonal difficulties should not be present. Most frequently, developmental dysarthria (affecting the facial area) and apraxia will be mixed and show components of each, so tone should always be considered in evaluation and intervention.
Before proceeding to further stages of therapeutic intervention, the clinician must first determine the following:

- whether body tone is normal or if there is evidence of hypertonicity of hypotonicity in the:
  
  1) entire body
  2) partial body (hemi-paresis, etc.)
  3) thoracic cavity and upper body
  4) facial structures
  5) tongue

Depending on the level and severity of the tonicity the following guidelines should be considered:

1. If abnormal levels of tonicity (hyper or hypo) are involved in the whole body - no specific intervention, i.e., just attention to the facial area will change this. Positioning, active movement and/or releasing movements will be needed to re-organize movement (tone) difficulties. Since the Prompt System is not intended to replace or duplicate physiotherapy intervention it is recommended that the Speech-Language Pathologist work with appropriate staff trained on overall movement management.

2. Partial body tonal difficulties, i.e., (hemi-paresis) will cause unequal muscle contraction to the mid-line of the face. Often other facial muscles will be used to compensate for loss of specific muscle control. The clinician must then analyze these abnormal muscle movements and begin to recognize where "over-movement" or "under-movement" will cause difficulty in rapid speech production or movement transition.

3. It is important that the clinician recognize incorrect breathing patterns or muscle movements that prohibit effective breath support for speech. If generalized tone is either too weak (hypo) or too strong (hyper) the thoracic cavity and muscles will produce a diaphragmatic breathing pattern, with a shallow, rapid breath. If such severe conditions exist and breath support is limited in this way, trunk control and balance in sitting may also be involved. In both of these areas, the speech-language pathologist should work with a physiotherapist or occupational therapist to establish good trunk control for the improvement of breath support, balance and sitting.
4. Too much muscle tightness (hypertonicity) in the facial area will make transition and accurate timing for retraction and protrusion of facial muscles difficult. Severe hypertonicity will effect the tongue tip often pulling it down and by showing retraction in the dorsal area. to decrease tone a slow, stabilized, consistent pressure is preferable. Muscles may need to relax or release at a reflex level and the stretch reflex must be inhibited. In these cases, the Speech-Language Pathologist must be aware, know how to identify, and stimulate or relax specific muscle groups. However, identification and treatment is best when done in conjunction with a trained physiotherapist. Too little muscle tone (hypotonicity) will often make tight contractions (retractions) of the facial muscles difficult and will interfere with tongue control. The tongue will look big, soft, often protruding over the front central incisors and around the dental ridge. Tongue tip control for lifting will most often be impaired, with the tongue functioning in unison with the jaw. Back tongue (dorsal) contraction will often be minimal. Progression of tongue innervation will need to be considered from the tip/blade to the dorsum. To increase tone on a specific muscle or muscle group, rapid movement is required i.e., tapping, brushing. Overall, body tone may be increased with large muscle movement requiring the use of major muscle groups for example running or jumping.

5. The tongue must be able to function separately from the jaw in order to perform quick isolated movements necessary for rapid speech. Normal tongue/jaw separation in children should occur by age 3-5 years.
Stage II - Supportive Speech Functions, Phonation & Breathing

In order to sustain speech a child must be able to maintain breath support and develop control for speech breathing. As explained in the previous section, tonal difficulties will greatly influence muscular support for breath control. As well as tonal influences, the child must also be able to maintain sub-glottic pressure and valving control (Warren 1989). Valving occurs at the level of the glottis, palate, tongue and lips and affects all sound production. Without the ability to control these functions the child will lose air pressure or have too much or too little glottic resistance and consequently have difficulty producing voiced phonemes, plosives, fricatives, affricatives and sibilants and sustaining breath support over longer durations for words or phrases. The ability to start and stop a controlled phonation is also very important. This control is the basis for phoneme production and the later interplay of complex productions that require complex valving and pressure (Lindblom & Letterman, 1986). Considering this, the clinician must then evaluate the child's breath control and phonation ability.

The following should be noted:

1. The child can produce adequate breath support for speech if there is evidence of:
   - a combination of abdominal and thoracic chest expansion
   - no evidence of clavicular breathing or shallow abdominal breathing
   - the ability to inhale rapidly and exhale slowly. (The ability to do this without phonation will be difficult for most children). The clinician should attempt to judge breath support adequacy by looking at breathing patterns at rest and then on demonstration of phonation, most often, in play activities.
• The ability of the child to produce a open vowel, i.e., /a/, /æ/, /a/ with consistent start/stop production on command. Until control of phonation is established, further steps should not be taken. Production need not be more than two seconds in length but must be under voluntary control. In children this control is often difficult and must be learned. The clinician as part of regular intervention procedures can use blocks to help the child understand the concept of a sound and then add blocks for successive sounds.

**Stage III - Single Movement to Combined Movement on a Single Variable Plan**

In normal developing children, around 6 months of age, one of the first areas to be exclusively used in the production of sounds is the jaw (Newman, Craighead & Secord, 1985). The jaw performs movements in a vertical plane and accomplishes four major things: 1) it allows the oral appature to be either open, providing little resistance, for vowel production 2) closes the oral appature completely so that the air stream is directed back and superiorly for nasal productions 3) enables the lips to approximate each other for early bi-labial productions and 4) lifts the front of the tongue, when closed, and the back of the tongue, when open to aid in the early approximations and productions of both tongue (blade-tip) sounds /l/, /d/, /n/ and /k/, /g/, /ŋ/. The independent functions of lip control and tongue control appear later. In Stage III it is important to consider how the jaw is functioning in combination with breath support and glottic valving. In order to maintain a base for all other phoneme features the child must be able to produce voiced/voiceless contrasts with varying degrees of appature opening.
A.  

**Jaw + Voice**

This stage begins by looking at maximum contrast within one variable (i.e., spatial plane). It is important to assess if movement transitions can be maintained in the same spatial plane before proceeding.

At this point an open vowel should be able to be produced with control.

Here we would check:

1.  \( m \rightarrow a \)  
   (time variable should shorten from
2.  \( b \rightarrow a \)  
   1 sec. to rapid transition)
3.  \( p \rightarrow a \)

Voicing is maintained in the first two combinations and the lip seal needed for the two consonants is minimal. The /m/ requires longer timing to become nasalized.

B.  

**Voiced/Voiceless Contrast Control**

If there is severe physical limitation or severe hypotonicity, the pressure seal for /p/ may be inadequate. Also to devoice may cause the child difficulty. If the child cannot differentiate voiced/voiceless production, this is where to begin. After voiced productions the client must be taught to control devoicing.
Stage IV - Adding a Horizontal Plane of Movement

This is a critical stage and one that is almost always overlooked in traditional methods. In this stage we are concerned with the child’s ability to use smooth and well controlled facial contractions as in /i/ and rounding as in /u/. Facial contraction, rounding and place of tongue contraction appear to be related. The function of both retraction and rounding in speech appears to aid the tongue in early speech production by influencing both place and amount of contraction needed for early vowels (i.e. /i/, /ɪ/, /ɒ/, /u/, and later, for consonants /s/, /ʃ/, /t/ etc). In other dialects and languages these consistencies are also apparent. In young children usually the retracted position of the horizontal plane is acquired first, however this may be somewhat child dependent. What is most important here is that all lower levels are maintained while adding an additional plane of movement and that movements are well controlled and smooth, without asymmetry or jerkiness. With well controlled movements at this level a child can begin to produce CV and CVC combinations; very consistent with early production abilities.

Often, children with a mild dysarthria or severe speech delay will have trouble with jaw control and facial movements. Young children (3-4 years) with "pure" phonological disorders usually show good ability at this level. However, developmental apraxia may begin to break down here as the transition between planes of movement begins.
A. **Jaw + Voice + Facial Contraction**

Once the above has been mastered, the clinician can add a second plane of movement. This additional movement will stress the system and use a different set of muscles, i.e., muscles used in contraction of the lips and facial area. The contraction of these muscles also generally effect the tongue tension of the anterior portion of the tongue. In other words, contraction of the facial muscles (retraction around the lip area) often helps to increase frontal tongue tension.

The clinician should now attempt the following:

1. /m/ ——> /l/
2. /b/ ——> /l/
3. /p/ ——> /l/

In children with more facial tone around the lip/cheek area, these combinations should be relatively easy. Difficulties will likely be seen when transitions between the two planes of movement are introduced, for example:

/m/ - /a/ ↓ /b/ - /a/ ↓ /p/ - /a/ ↓
/m/ - /l/ ——> /b/ - /l/ ——> /p/ - /l/ ——>

If this series is mastered then the vowels and consonants may be reordered for varying combinations and co-articulation. All combinations should be attempted with accuracy before proceeding. For example:

/l/ - /a/
/m/ - /a/
/a/ - /b/
/l/ - /p/
/a/ - /m/
/m/ - /l/, etc.
It is important at this stage to consider the following:

- an evaluation of rounding and tension in the facial muscles must be made to determine the ease or difficulty, for quick transitions or retracted or protruded movement.

- For children with developmental disorders and/or neurological involvement, attempts should be made to get control of early motor sequences before proceeding. What is critical however, is that as soon as usable sound sequences can be formed either approximations to real words be formed or small words combining those sounds be formed and made useful. Every attempt should always be made to make the entire process a pragmatic/communicative experience, even though it is recognized that continuous repetition to practice motor skills will be necessary during some parts of the intervention process.

B. **Jaw + Voice + Facial Contraction + Rounding**

If protrusion or rounding (contraction) of the obicularis oris and accompanying facial muscles can be easily produced - programming can continue using the following sequences:

(a) \( /a/ - /a/ \)

\( /a/ - /u/ \)

\( /a/ - /o/ \)

- \( /o/ \) requires more tension and contraction across the upper lip than does \( /u/ \) and the jaw position is lower for \( /o/ \) than for \( /u/ \).

(b) \( /o/ - /u/ \)

\( /u/ - /i/ \)

\( /o/ - /i/ \)

\( /i/ - /u/ \)

\( /i/ - /o/ \)
These vowel combinations (once established) should then be incorporated into the consonant sequences already established. **Voicing control** should keep pace with sequence control, i.e., vowel production or 3 or more vowels should now be able to be produced accurately while early CVC combinations are attempted.

Possible combinations may now include:

/m/ /a/, /æ/, /i/, /o/, /u/ /m/  
/b/  
/p/  

For example, mom/pop/bam/mop/bee/, etc.
Stage V - Sequential Control of Facial and Oral Movement

To begin intervention at this stage, control of phonation, range of jaw movement, facial muscle contraction for both retraction and rounding should be established and under good voluntary control. These elements, as mentioned earlier all interact and form the basis for speech support, voicing contrasts and flexible and independent movement of the articulators that are necessary for complex speech. At this level the tongue is finally brought into play as an independent and flexible articulator. Simply put, this means that the tongue now begins to act as separate from the jaw and use its various muscle groups to perform more and more complex sets of movements. This separation and multiple, flexible control does not happen all at once and is a slow process. In normally developing children, this separation and complex, integrated coordination begins around 9 months but is not completed until usually after the fourth year.

In children with motor-speech production issues this phase is usually lengthy and requires the clinician to carefully evaluate what areas of tongue control do exist for the child. For example, some children may be able to release the tongue blade area but not the tip or the tip but not the dorsal area. Others may have some use of the blade and tip but limited used of the mid to dorsal sections. This knowledge will greatly aid the clinician in making decisions about the intervention progression and how to facilitate the integration of various muscle groups.

Jaw + Voice + Facial Contraction + Rounding + Tongue Control

As mentioned this can be a very lengthy stage in treatment and traditionally this is the stage where most clinicians begin treatment. It is probably obvious now why this is in error. Every new spatial and motor variable added to the system places on it additional stress. If there are tonal problems these become more evident, transition time becomes either too rapid and small or too slow and large. Breath support and
Phonation also begin to break down as more is demanded and previously isolated, correct productions, lose control. It is not always possible or realistic for the clinician to expect the child to have every stage, described above, perfectly controlled before proceeding to the next stage, however, the clinician cannot lose sight of all the variables involved and normal movement sequences and mid-line movement must always be aimed for.

B. At this level, tongue control and differentiation of movement is begun. In most cases this should proceed from tongue tip/blade control to back dorsal contraction. However, as in everything, there are always exceptions. In children, with increased facial tone, back tongue movements may be more accessible and in a retracted position. The clinician must always use their best judgement and whatever functional muscle movement the child has, to develop productive speech.

With the above exception, the following introduction of phonemes is usually acceptable:

\[
\begin{align*}
\text{t} & \rightarrow \text{t} \\
\text{d} & \rightarrow \text{d} \\
\text{n} & \rightarrow \text{n} \\
\text{f} & \rightarrow \text{f} \\
\text{s} & \rightarrow \text{k, g} \\
\text{s} & \rightarrow \text{l, r} \\
\text{z} & \rightarrow \text{z} \\
\text{z} & \rightarrow \text{z} \\
\text{mid/back vowels} & \rightarrow /\varepsilon/ /\text{i}/ /\Lambda/ /\nu/ \\
\text{diphthongs} & \rightarrow /\text{oi}/ /\text{ai}/ /\varepsilon/ /\text{ei}/
\end{align*}
\]
Points to consider:

(a) every consonant/vowel combination should be presented no more than 2-3 at a time. At least one should be established before a new one is introduced.

(b) with the PROMPT system, affricatives and fricatives are usually easy to achieve, so these may be introduced earlier than in other systems. Phonemes that occur with low frequency and do not contribute greatly to speech intelligibility, should be taught last, unless the child can produce them easily or especially wants to learn them.

(c) tongue tension is critical for all consonants and vowels, however, it can be introduced using mylohyoid prompts that increase tension of the selected muscle groups. The child should not, as with all prompts, be expected to maintain this at the beginning. As the child's system is stimulated and control at lower levels is established, more and more muscle innervation will be seen. The system will do more of the work, the clinician less.

Stage VI - Sequenced Movement on Multiple planes.

Voice + Jaw + Facial + Contraction + Rounding + Tongue Control + Timing

At this stage the clinician becomes increasingly aware of the timing and transition between all the foregoing motoric aspects of speech production. Specifically, this not only relates to accurate production of all phonemes but accurate timing between and within them. At this level the clinician is concerned with word or short phrase production.

Realizing, however, that timing has actually affected production of phonemes and needs to be emphasized much earlier in treatment, it is necessary to understand how these earlier pieces relate. For this reason this section will return to the three earlier motor control components and work forward.
The following shows the Interactions and development of the timing hierarchy:

timing co-articulation production

↑

segmental production

↑

voicing onset time

A. Voice onset time/voicing errors

At stage II we discussed the necessity for the child to be able to control and recognize elements of voicing control. We stated that they should be able to produce an open vowel with consistent start/stop production on command. (Oller, 1976)

The reasons for this were as follows:

1. To enable coordinated phonation with breath support

2. To equalize and help reorganize and where possible, tone within the necessary muscle groups, i.e., face and chest, to produce controlled phonation. Depending on the amount of tone deviation from normal (hyper or hypo tonicity) this task will be easier or harder to achieve.

• Hypotonicity will tend to provide little support for breath functions and poor ability to control air flow. The child here will often produce weak voicing and lose air rapidly, being unable to sustain vowels. (Voicing → breathiness).

• Hypertonicity, as well, will tend to (again) provide little breath support (this time because the chest is constricted) but also, the laryngeal structures will be overly tense. Vowel production here may be difficult to elicit or may sound strangled or strained and be of short duration. (Intermittent voicing → O).

• Nasality factors will also be effected by timing and tone.
In conditions where there is little or sluggish movement of the oral structures (hypotonicity) the soft palate will often not contract significantly to produce closure. In this case increased pressure and upper body tension will produce some improvement. With hypertonicity the velum may show minimal or lack of movement due to the inability to "get free" of excess tension. This condition is extremely difficult to correct and needs to be considered within the framework of the entire body; especially the chest and head area.

Nasality will often occur as timing lengthens or as the velum is unable to obtain closure, as in the cases of dysarthria. In apraxia, it may occur because the system cannot handle additional stresses and will always revert to the simplest level of movement, i.e., the longer the phonation the more controlled the muscle groups must be to maintain the voicing elements without producing nasality:

<table>
<thead>
<tr>
<th>least control</th>
<th>neutral</th>
<th>most control</th>
</tr>
</thead>
<tbody>
<tr>
<td>nasality</td>
<td>voiced</td>
<td>voiceless</td>
</tr>
<tr>
<td>/m/</td>
<td>/b/</td>
<td>/p/</td>
</tr>
</tbody>
</table>

In children with motor-speech disorders the degree of muscular contraction will determine how much difficulty the system will have in flexible coordinated movements that effect timing of velopharyngeal control. In children with a developmental dysarthria this will be a consideration, however, unless the tonal condition is pervasive, as in cerebral palsy, the child will have a better prognosis. In developmental apraxia, the issue of nasality should be seen only at the level of words or phrases where sequential and timing errors may confuse manner issues. At the phoneme level timing should be intact.
Activities in treatment may be assessed along the following lines:

1. **Voice on/off (+ -)**
   
   a. Ability to produce an open vowel on command.
   b. Ability to produce/stop an open vowel on command with a 1 second interval.
   c. Ability to produce/stop two open vowels of set duration.
   d. Varying duration of two open vowels.
   e. Ability to produce/stop three vowels of set duration.
   f. Ability to produce/stop four vowels of set duration.
   g. Ability to sequence four vowels of different durations.

It is critical to establish this level of control for vowel duration before adding the element of devoicing that occurs with consonant productions.

Things to observe while checking voice onset time that are related to jaw movement for different open vowel positions are as follows:

- Jaw should be in mid-line position
- Jaw should move vertically in line with the maxilla and not show excursion either anteriorly or posteriorly.
- Jaw should move smoothly, without jerkiness.
- Jaw should not show reduced or over extended excursion at a full open position.

Intervention strategies should be put in place for any of the above jaw movement deviations.
2. **Voice on/off + No Voice + Jaw Control**

At the beginning of Stage III we had considered jaw + voice and had looked at the production of open vowels and bilabials (consonants). The consonants were along a continuum from nasalized to devoiced. To make our task simpler at this level the clinician should limit themselves to only:

a. Voice on /b/  
   / off

b. No Voice on /p/

Realizing that all activities should be brief and within (as much as possible), the context of language activities, the following hierarchy is provided to help the clinician break down the steps that should be considered in the control of voicing at the simplest levels. The breakdown is not meant to followed exactly but more to aid the clinician in understanding the small step approach that must be undertaken when trying to find out where the voicing breakdown is occurring, and to help the child achieve control over this area. As with all tasks suggested in this chapter, it is helpful to use blocks or small animal figures to represent the voicing elements. Where possible the clinician should try to use vowels and consonant vowel combinations that have meaning.

The examples given below use nonsense syllables simply because no meaningful words could be constructed at this level. Clinician's are encouraged to come up with their own syllables as appropriate for each child. Consideration should be given to the following steps;

a. Voiced CV of set duration /ba/.

b. Producing a C /p/ and V /a/ of set duration without attempting to join them.

c. Producing two voiced CV or V of set duration.

d. Producing a sequence of two C V C V (unvoiced) (plosives) without attempting to blend them.
e. Producing 1 CV /pa/ and VC /ap/ with controlled blending.

f. Producing 2 CV's or VC's with controlled blending.

h. Producing a VC voiced (non-plosive) /ab/ and one CV unvoiced (plosive) /pa/ (this may be easier to accomplish as /ab/ /a-p/.

h. Producing a sequence of 4 bilabials CV or VC syllables of voiced/voiceless contrast, i.e., /ba pa ba pa/ /pa ba pa ba/, etc.

i. Varying duration of the vowel in step #h.

Once the child has demonstrated and/or mastered this level of control, (+ -) voice production + jaw, we may then add facial contraction /i/, rounding /o/ /u/, and tongue control. The clinician must remember that each additional movement plane will add stress to the system and require integration and reorganization of the movement sequence. As previously mentioned, if it is established that the child has good control of voicing at the voice on/off + no voice level, the clinician may choose to bypass other steps; always realizing that breakdown at any level will require the clinician to go back and check what additional stress is causing the breakdown to occur.

B. Segmental Errors

1. Voice + No Voice + Facial + Tongue Control

The more complex the motoric sequences become, i.e., the more planes of movement required; the more voicing and timing errors are likely to occur. For example, it will often be easier for the child to produce a voiced segment before a no voiced segment, e.g.:

\[ b \, \text{and} \, t \]

\[ m \, \text{and} \, t \]

than to maintain voicing in a final position (which requires a sustained exhalation and coordinated control of laryngeal and breath support systems. As well as sustained control, transition and timing of jaw and tongue movements must be maintained. e.g.:

\[ b \, \text{and} \, d \]

\[ m \, \text{and} \, d \]
2. **No Voice + Voice**

To move to a devoiced segment before a voiced, it is usually easier to begin at a CVC level where both initial and final C are unvoiced. For example: pop, pipe, peep, or with the additions of facial + tongue control: pat, tap, toot, feet etc.

Due to the duration (timing) and pressure needed to produce certain consonants and vowels, the more place variables are changed the more difficult transitions will be to maintain. For example:

**Vowel Duration**

<table>
<thead>
<tr>
<th>facial contract/rounding</th>
<th>jaw</th>
<th>tongue</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/i/</td>
<td>/iy/ /o/ /ur/</td>
<td></td>
</tr>
<tr>
<td>long</td>
<td></td>
<td></td>
</tr>
<tr>
<td>/a/</td>
<td>/Z/</td>
<td></td>
</tr>
<tr>
<td>short</td>
<td></td>
<td></td>
</tr>
<tr>
<td>/ɪ/ /ɛ/ /ʌ/</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Consonant Duration**

<table>
<thead>
<tr>
<th>nasal</th>
<th>voiced</th>
<th>devoiced</th>
</tr>
</thead>
<tbody>
<tr>
<td>anterior</td>
<td></td>
<td></td>
</tr>
<tr>
<td>/t/</td>
<td>/d/</td>
<td>/n/</td>
</tr>
<tr>
<td>/t/</td>
<td>/d/</td>
<td>/n/</td>
</tr>
<tr>
<td>posterior</td>
<td></td>
<td></td>
</tr>
<tr>
<td>/r/</td>
<td>/g/</td>
<td>/k/</td>
</tr>
<tr>
<td>long</td>
<td></td>
<td></td>
</tr>
<tr>
<td>short</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In general, the more planes of movement (vertical to horizontal, anterior to posterior) and timing variabilities that the child must control the more difficult the production will be. For example, on the following pages, diagrams of phonemes and the short words they produce are plotted in a three dimensional framework that denotes jaw height or vertical placement, anterior to posterior placement and time or length of production i.e., (nasal/voiced/voiceless) contrasts. For example, from the first figure, the CV /ma/, to the final CVC VC /sneik/, changes in complexity among the multiple domains are illustrated. It is important for the clinician to remember that 1) there are transitions among differing planes of movement (jaw height
and place of contact of the 'target' movement) and, 2) relative timing must be seriously considered when evaluating 'breakdowns' in speech production skill or selecting of a functional lexicon.

In our experience with normally developing children we realize that the first words to be used are often cv's or canonical shapes (Oller, 1975/76). These are almost always produced using primarily the jaw with some help from the lips and minimal involvement of the tongue. Some examples of early words are /ma/, /mama/, /ʌ/ for up, /mor/ for more, /mu/ for cow, /baba/ for baby, /næ/ for no. It is not until later that words such as; cat, go, mine, doggy and cookie are produced and even then simplification and assimilation processes predominate, as in /tutɪ/ for cookie or /gagi/ for doggy. An early /ɡa/ production at 3-6 months produced with the raising and lowering of the jaw and the whole tongue with a slightly elevated dorsum is not the same /ɡa/ of later years where the jaw is kept stable and a very controlled area of contraction in the dorsal area is lifted. The same applies to all early vs later productions in terms of articulators used and amount of individuation of the muscle groups involved. In intervention the clinician must remember and appreciate these sequences and use lexicons that incorporate these principles to help the child get the most productive and use of their system.
Graph Interpretation
- relative timing of each segment (horizontal)
- jaw height
- dashed line: point of contact/construction from lips to lingua velar (diagram: stylized trajectory of movement
Graph Interpretation

- relative timing of each segment (horizontal)
- jaw height change
- point of contact/construction from lips to lingua velar (diagonal)
- stylized trajectory of movement
Realizing the above, the clinician at the word or phrase level, is now interested in overall timing as it relates to:

1. intelligibility
2. smooth well coordinated transitions
3. stress markers that determine appropriate syllabication and mark meaning.

With the PROMPT system the clinician will be using the sequenced prompts to now control these elements, as well as to provide extra emphasis for stress markers, i.e., /b.k/ as opposed to /b.k.l/ and to indicate timing for vowels that need to be either shortened /b.a.l/ or elongated as in /s.a.t/. Timing between words will also now be controlled by providing input on initial start or stop sequences. Prompts may or may not be given for every word, depending on the client's needs.

Stage VII - Prosody/Suprasegmentals

This stage is a culmination of all stages before it, and can be described by the basic physical qualities of amplitude, duration and fundamental frequency of the voice. Although controlled through motor speech functions, prosodic features convey more than words, and they function to decode the communicative intent of word use. Prosody begins to be developed very early in communication attempts, and well before control of the speech-motor system has been mastered. In normal speakers, prosody is rarely disordered, however, several groups, have been identified as having prosodic disorders, among these are adults and children that clearly evidence motor speech disabilities.
Guiding Principles

- the more central the vowel and consonant and the more stable the voicing component, the easier the production, i.e., /dʌd/, /no/.

- the more deviant (extreme) the production, the more difficulty the child will have in maintaining smooth transitions without sacrificing a variable such as voicing or duration, i.e., /net/ or /kod/. When translating these principles into therapy intervention it is important the clinician choose initial word lexicons that maintain central or long vowels and consistent consonants /dad/, /man/, before progressing to more variable durations /pet/ /take/, or combinations thereof e.g. /red/, /pair/. Often clinicians will experience a child sacrificing one variable/feature for another in a more complex set e.g. / kod/-/dod/, /dog/- /gog/. When the sacrifice is too great for the system to maintain, the process of consonant deletion will occur. For example, /shu/ becomes /u/, and /lait/ becomes /la/ or /jal/.

C. Co-articulation Processes (multiple planes)

At this level the clinician should expect the child to have some control of timing aspects related to voicing, and segmental control or at least to recognize that if the child is severely impaired, trying to produce phrases of more than 2 to 3 words in length may be the maximum one can expect while maintaining intelligibility. Remember at this level; tone = phonation = voice — relates to jaw — facial — tongue, etc., and if these are not well controlled, intelligibility will inevitably suffer.
The following section will deal with intonation, stress, juncture and speech rate, and how the clinician may develop these in treatment.

A. Intonation

Intonation can be described as the vocal pitch contour of an utterance or the way in which fundamental frequency changes from syllable to syllable or even segment to segment. Intonation is effected by several factors including stress and tongue position.

In PROMPT treatment the therapist can stimulate intonation patterns by:

1. Providing a complete phrase that is pre-programmed, i.e., "I want a cookie" vs. "Do you want a cookie?".

   In pre-programmed phrases the clinician controls for timing and stress variables by increasing both the pressure and timing parameters so that the /l/ in cookie is unstressed for the first phrase, but stressed and held for the second, thereby producing an inflected rise.

2. Providing sequential word patterns, and controlling for stress and timing as in: "more" ↓ vs. "more?" ↑

3. Using a Vocal II or Speech Viewer to sequence phrases and words and check visual spacing and rise. For example, in the word "more", using the Vocal II at a F2 frequency setting, a clear pattern of rise vs. fall can be seen. In PROMPT treatment this translates into an extended vowel time for the inflected word and increased tension on the final "r". With PROMPT, differences will be signalled using timing and pressure cues.

In developmental verbal apraxia, intonation patterns are programmed at the whole word or phrase level. Intonation patterns are usually easier than is marking stress appropriately, or coordination of voicing and place variables. In children with dysarthria, transition time between place and coordination of smooth sequences becomes an issue and may effect intonation, stress and voicing.
With children, clinicians can use activities that provide whole body movement to begin emphasizing rise vs. fall in a word, by activities such as jumping. Whole body movements give abstract concepts such as inflection, a more realistic frame for a child and also produce increased tone in muscle groups, that may aid a child in increasing and holding tension to change frequency. As the child is able to control these factors better, activities may proceed to table activities, such as xylophone, where different patterns or stress points may be tapped out.

Since amplitude is part of intonation and amplitude shifts are created by physical tension in muscle groups that influence frequency changes, the therapist should consider the following levels when working toward intonation changes.

1. Begin using a single vowel and change timing and pressure, for example:

   For /a/ _____ ↑ the jaw is moved slightly up out of the /a/ position, and tension is increased on the mylohyoid at a B position. (See PROMPT Manual, Mylohyoid figure, page 22.) This increases vowel length and provides tension for rise frequency.

   For /a/ _____ ↓ the clinician lowers the jaw to 3-4 position and maintains this placement. (See PROMPT Manual Jaw Positions figure, page 21.)

2. Next, the clinician should contrast words with all voiced elements, before adding voiceless contrasts. Where all voiced phonemes are present, timing (duration) and tension will increase on the last consonant (realizing that the time for the vowel preceding that consonant, will lengthen), for example:

   /komɪ/  /morɪ/  /dəɡɪ/
3. The final level would be to incorporate voiced and voiceless phonemes in word production. This will necessitate greater control for timing and transitions and will also place tension changes on the vowel preceding the final voiceless consonant, i.e., /ʃ/ s/, since only voiced phonemes can reflect rise. After this point, the clinician may add well controlled sequences into programmed phrases, and begin to work on generalization to new, but similar phrase types.

B. **Stress and Juncture**

**Stress** refers to the degree of prominence or importance given to some part of an utterance and is usually discussed with respect to syllables. Acoustically, stress is carried primarily by the vowel segment within a syllable. However, emphasis or stress can also be placed on initial or final consonants.

With the PROMPT system, the clinician takes into account stress variables for word and phrase production and will increase timing for vowels and pressure for consonants to influence the importance of the segment.

A problem the clinician may experience with children who are at sentence level and totally unintelligible is that of pre-programming the phrase quickly enough to match the intended meaning or normal perceptual match. For example, in the word "cabinet" it is relatively easy for the clinician to equalize stress on all syllables ca, bl, net, or to stress the final syllable ca, bl, net. However, it is much more difficult to increase the transition time between the syllables and maintain proper stress. This is due to the inability of the hand to move as fast as the articulators, and be able to control for all variables effecting production.
With developmental apraxia of speech, it appears that stress can be programmed at a word level and if there is no dysarthric component, will be spontaneously generalized into phrases. In children with a dysarthric component, stress will not necessarily be generalized and they may need programming at a whole phrase level to be maintained. Timing and transition difficulties inherent in dysarthria make stress a variable feature on a spontaneous level.

As with stress, juncture indicates the importance of the utterance but goes beyond into word order and meaning. Juncture or pausing, marks special distinctions in speech or certain grammatical divisions. It also may be used to make distinctions between similar articulations such as "common" and "come on".

The PROMPT system can be used to help control for timing and rate variables that influence juncture. It appears that juncture is often difficult for children with developmental apraxia of speech to maintain as are stress and VOT (voice on-set time) variables. This is likely due to the fact that while juncture influences grammatic meaning and is grosser in its' level of control - or less subtle in its' timing, all areas require integrated motor control and also function to encode meaning for speech. In children, juncture must be taught along with stress, mainly because grammatical forms and semantic understanding have not been completely developed. With children, other gross and fine motor activities using body parts with music, i.e., instruments, peg boards, buzzer boards, can be used to visually and acoustically represent juncture. Activities should proceed from:

1. Use of whole body - movement, start/stop.
2. Use of legs/feet - marching in time.
3. Use of hands - clapping simple to complex patterns.
4. Use of objects - i.e., instruments, to tap out rhythms and patterns.
5. Visual clues - to stimulate acoustic patterns in a sentence: peach, pear and banana.
6. Visual stimulus, at a more representative level, such as: coloured pictures to sequential series.
C. **Speech Rate**

Speech rate is directly effected by the overall range of articulatory movement. As the speed of speech movements (articulation) increases, transition time, movement range, and segment durations decrease. In order to speak faster, but maintain intelligibility, a normal speaker must continue his articulatory accuracy (place) while reducing his range of movement. This naturally implies that breath control and phonation abilities are well coordinated and controlled.

With disorders that involve sequencing and motor speech skill, the clinician must remember some earlier stated premises that have to do with muscle tone and transition abilities. They will now be restated with regards to rate of speech.

Children with hypertonicity have increased resistance to normal movement, e.g. a child with a spastic dysarthria will have trouble with phonation because of tight or constricted thoracic muscles. This will give a shallow breath support system and will make voicing difficult due to lack of pressure and regulated airflow. At the same time, the laryngeal muscles will be tight and produce irregular voicing. Facial movement will also show deviations, often excessive jaw excursion will be noted, and retraction and protrusion of facial muscles will be limited. Movements will either be "locked" into retracted or protruded positions or be neutralized without either movement being completed. Hypertonicity effects movement transitions primarily because muscles do not have "freedom of movement". Instead they become fixed in a position, while they "struggle" to move into others. Transition time slows, while movement range among some articulators increases, notably jaw excursion. In other facial muscles, i.e., lips and tongue, range decreases but transition time continues to be arduous. In general, we could say that speaking rate decreases while breath support and phonation are inadequate often producing a strangled, breathy production.
In cases with a hypertonic (spastic) dysarthria, the clinician must strive to equalize tone and prevent the jaw from over extending. As has been stated before, the tongue will not usually show freedom of movement from the jaw (usually at the tip), and will retain a retracted (bunched) position posteriorly. The clinician can use the PROMPT system to help control and stimulate movement production. With more normalized articulators, the clinician may then help the child to produce more accurate articulatory movements and provide for a more regulated transition time. In hypertonic (spastic) dysarthria, the goal should be more regulated movement with smoother transitions. Speaking rate will then more closely approximate normal, resulting in increased intelligibility.

Hypotonicity or flaccid dysarthria results from too little resistance in muscle movement. The obvious result of this is a restricted range of movement producing too short a transition time. As mentioned before, phonation and voicing are poor because there is too little breath support and an inability to control airflow. In other words, air escapes too readily. The result is often that phonemes are intelligible at the beginning of a phrase but quickly become unintelligible as there is poor breath control and articulator movements reduce in range. Movement sequences may start with adequate range but reduce quickly. Speech rate may sound as if it is increased because segment durations collapse and articulatory control is too reduced in movement to produce intelligibility.

With flaccid dysarthria, the clinician’s goal is to increase movement sequences, range of movements and strength of contacts while maintaining adequate breath support. In some clients this may mean that only two or three words maybe intelligible per breath. Always the goal should be increased intelligibility with control. With the PROMPT system, the clinician may increase pressure variables for each phoneme. This will aid the child to produce better bilabial and lingual contact, more precise placement and will lengthen duration, thereby increasing controlled rate of production.
As in all treatment, breath support and phonation must keep pace with articulatory movement sequences.

Studies on acquired apraxia indicate that the primary basis for apractic speech errors are the temporal and spatial incoordination of the articulators and voicing. In clear cases of developmental apraxia of speech there should be no muscle weakness or spasticity. In other words, increased or decreased rate in apraxia is postulated to do with a sequential incoordination and as such is especially sensitive to timing errors. In children, we must be careful to assess for dysarthric components or elements of oral apraxia, since these are often part of the production difficulty. Clear cases of "pure" apraxia in children do exist but with much less frequency.

If a child is free of dysarthric (tonal) difficulties, then the goal of treatment becomes both a regulatory or patterning and a phonetic building procedure. Equalizing rate of production entails not only controlling for spatial accuracy (planes of movement) but timing, stress, and overall segmental durations. The PROMPT system allows the clinician to "program in" articulatory sequences and timing thereby creating a match to the already formed system, or providing an "overall" map for the intended phonetic feature or phoneme combinations.

As has been stated, children require the building of a normal 'map', so the clinician's job is one of teaching each phoneme and combining these to produce well timed and coordinated sequences. With "pure" apraxic children, controlling rate is considerably easier because tone is not a problem and once sequences are learned they are usually produced with adequate range and transition time. Stress and juncture are also built into programming at a word and phrase level, albeit they may need re-working when the child begins to use spontaneous productions at the sentence level.

In summary, rate of speech production in disordered speakers is directly proportional to tone, breath support, voicing, and transition time. Each of these areas must be evaluated if the clinician is to understand how to help a child to speak with control and intelligibility.
Conclusion

In conclusion, the PROMPT system and its therapeutic intervention hierarchy are tools for helping define the levels of speech break down, the interplay between them and the control needed for motor-speech production. The true guiding principles must always come from the clinician's knowledge and understanding of motor control theory, and how motor speech production is intimately and innately tied to linguistic operations in both normal and deviant speakers. Only when this is accomplished, can we hope to change motor speech patterns and produce changes in our clients that allow them true freedom of speech.